Environmental Earth Sciences (2024) 83:148
https://doi.org/10.1007/s12665-023-11353-9

ORIGINAL ARTICLE

Geological disaster information sharing based on Internet of Things standardization

Guocai Zhang[1,2] · Xue Liu[1,2] · Fangkun Zheng[1,2] · Ying Sun[1,2] · Guihong Liu[1,2]

Received: 24 July 2023 / Accepted: 1 December 2023 / Published online: 28 February 2024

Abstract

Nowadays the recent development of new information generation processes in the Internet of Things (IoT) is applied in various factors such as the development of modern sensors, wireless networks, big data applications, automatic monitoring systems, etc. Landslide disaster monitoring is an important and practical direction of Internet of Things technology in a disaster monitoring system, which has the advantages of low cost and mature technology. With the continuous development of IoT technology, standardized data sharing and interoperability have been put forward on the agenda. Based on the Open Geospatial Consortium (OGC) Sensor Thing Application Programming Interface (API) standard, this article analyzes landslide monitoring data sharing and interoperability from the data model, shared service content, and system construction and provides a reference for the standardization of geological disaster data sharing and interoperability regarding IoT applications. Due to the characteristics of a simple layout, strong anti-damage and self-healing ability, self-organization, etc., based on the ZigBee multi-sensor and wireless Mesh network, it is widely used in the data collection and transmission of geological disaster monitoring systems. The experimental analysis is carried out based on various parameters namely computational cost, power utilization, fitness function, danger rate, evacuation time, total travel time as well as root mean square error. Finally, the results conclude that the proposed approach attained better performances in terms of cost, power utilization, and error rate.

Keywords Internet of Things · Landslide monitoring · OGC standard · Sensor things · Landslides · Geological · Disaster

Introduction

The Internet of Things (IoT) is the technology that enables us to connect with other systems and exchange data through the Internet. The role of IoT in disaster management is to identify the hazards and warn in the early stages to rescue the affected areas, money, and resources using a server-application technology (Yang et al. 2019). In modern information technology, the data for climate, weather, ocean, and water were not accessible. The cyber security approaches are applied to avoid network access regulations and failure to utilize the proper protocol of cyber security (Salam 2020). The IoT is also used to manage the tracking of agricultural lands, IoT-based frameworks, and minimal human intervention. Smart agriculture based on IoT includes crop, farm, water, waste, nutrition management, and so on. The system enables communication and connection between internal and external state-embedded technologies (Sinha and Dhanalakshmi 2022). China is one of the countries with the most serious geological disasters in the world. Among them, landslides and mudslides are the main types of geological disasters that cause casualties. Strengthening the prevention and comprehensive management of geological disasters is the contribution of the Party Central Committee and the State Council to the construction of China's national defense and disaster reduction system. The wide application of the combination of the Internet of Things, GIS technology, high-precision geographic surveying and mapping technology, and displacement monitoring equipment has greatly improved by providing early warning. The practice has proved that it has good reliability, stability, and real-time communication.

✉ Guocai Zhang
zguocai@cccc4.com

[1] CCCC Fourth Harbor Engineering Institute Co., Ltd, Guangzhou 510230, China

[2] CCCC Key Laboratory of Environment Protection and Safety in Foundation Engineering of Transportation, Guangzhou 510230, China

GPS and CORS systems provide an effective all-weather, high-precision, automated data collection method for landslide disaster monitoring. However, the use of a satellite positioning system to monitor slope displacement has the disadvantages of a low degree of freedom in monitoring point selection and high cost, especially when combined with the mobile communication method of a wide area network, the management and operation cost is relatively high, therefore, professional displacement monitoring equipment still has a wide range of applications. With the advent of the 5G era, the application of 5G technology has brought richer monitoring content, higher monitoring capabilities, better information processing and analysis, and faster early warning capabilities to the field of disaster monitoring.

The geographical information helps to develop the social and economically in the world. To prevent the disaster the geological disaster information construction builds an integration database that accesses the information through that database and manages the geographical disasters. A large number of data were present in a geological disaster which may include complex data, wide range, and complex database is commonly known as spatial data. To control and prevent regional geographic disasters evaluation databases such as online analysis (OLAP), data mining, and data warehouse are used (Zhang 2020). The spatial data have the main role to improve the risks of geographical disaster tolerance capacity, disaster response capacity, financial losses, and reducing human, respectively (Chen and Li 2020). The localities with volcanoes, floods, landslides, and earthquakes are monitored through the monitor sensor networks using online analysis. Few networks also alert in early-stage of major geographical disasters to reduce property loss and causalities (Durrani et al. 2019). Nowadays social Media are an important source for sharing information about disasters with the help of information technology. It helps the residents people to collect information about the outdoor situation and announcements from the governments during disasters. The affected people can safely move to the major locations to prevent disasters (Zhuang et al. 2020).

The geographical hazard monitoring system in the Internet of Things is also information technology. It helps to monitor the incident areas before and further information to the people so that they people can able to vacate the area and find safer places to reduce the loss of property and people (Gao et al. 2020). The flood disaster is also a most dangerous one that affects the people and causes the loss of properties and causalities. This may mainly be used for forecasting, flood monitoring, and management (Chen et al. 2021). With the rapid development of fifth-generation Internet of Things (IoT) technology, consumption levels increased in the urban population and rural populations. The improvement of quality e-commerce agricultural products using the fifth-generation Internet of Things has the safest ecological environment. It usually monitors smart cities, food traceability, smart homes, industries, and so on (Zhu et al. 2021). In geological disasters, the IoT plays a significant role in providing alert signals to people through cameras, sensors, and wearable devices. It is integrated with artificial intelligence and machine learning models to decide the disaster. The ground cracks are deployed by IoT sensors and perform efficient communication due to the presence of advanced data visualization technology. The IoT devices act as central data that transfer the collected data through sensors and are analyzed by edge devices. The IoT provides more responsible factors in disaster management systems that provide real-time data, infrastructure monitoring, and maintenance of rescue operations with better communication.

At present, there is still a lack of research on building a landslide monitoring system that conforms to the IOT information-sharing standard from the perspective of standardized information-sharing and interoperability. This paper takes geological disaster data sharing and interoperability standardization work of the Internet of Things technology and provides a reference. The major contributions of the article are delineated as follows.

- To analyze landslide monitoring data sharing and interoperability from the data model, shared service content, and system construction.
- To provide a reference for the standardization of geological disaster data sharing and interoperability based on IoT technology.
- To determine the geological characteristics, hydrology and water conservancy, and other factors of the target area.

The remaining section of the article is arranged in the following manner. In "Introduction", the basic information and existing research methods are presented. The research methodology of geological disaster management is explained in "Research methodology". The experimental results and their key findings are discussed in "Results and key findings" and "Conclusion" concludes the article by determining efficient communication in the disaster management process.

Information sharing procedure

Zhu et al. (2021) illustrated the safety of the ecological environment based on the 5G Internet of Things. RFID (Radio Frequency Identification) technology was established which could communicate between people and things. As a result, the e-commerce business growth rate was 30%. The established method promotes agricultural products and solves the problems obtained in traditional agriculture. Meanwhile, it does not scan the products in a particular place. Wei et al. (2021) discussed satellite-terrestrial communication networks in marine activities based on IoT. A survey on maritime communication was obtained by maritime communication networks (MCNs). As a result, three technologies were applied to validate the performance of the model. Meanwhile, large performance losses occurred, so simple integrations are avoided in the remote sensing monitoring process.

Data monitoring

Gao et al. (2020) illustrated the geological hazard monitoring system in IoT IoT-based mesh network. Mesh network worked under the hardware platform of TL-WR841Nv8 which was constructed and developed by OpenWrt and used in wireless mesh nodes. The established method was tested in three sections such as laboratory, campus, and lakeside. As a result in the laboratory and campus, better performance was obtained. But on the lakeside, the performance was poor due to the large terrain difference. Meanwhile, the discussed method was not applied in field application. Liu and Dhakal (2020)illustrated mineral remote sensing monitoring for achieved data transmission through wireless communication technology based on IoT. NFC (Near Field Technology) was obtained to transmit and store the information through the network. NFC technology is very simple and its connection speed is faster. Principal components analysis (PCA) is a data set that eventually reduces the correlation between bands. Minimum Noise Fraction (MNF) was done for dimensionality and noise reduction. As a result, the ALOHA algorithm was used to ensure the data experimental data shown at different intervals were 10,15,20,30 and 50. Meanwhile, numerous users are needed in heavy load conditions. Kaur and Sood (2020) explained a cloud-fog-based framework by using an Artificial Neural Network (ANN). The different environmental conditions were to be continuously monitored and analyzed by IoT. The severity level of the drought was estimated in (ANN). The parameters of ANN were optimized by a genetic algorithm (GA). As a result, GA obtained the system more accurately. On the other hand, for large networks, high processing time was needed.

Network Verification

Savari et al. (2020) discussed IoT-based real-time load forecasting in Electric Vehicle (EV) and Charging Station (CS). State-of-the-art technology was obtained which improved the charging scheduling of EVs. The established method was more secure and did not share end-user information in the aggregator. The database SQL (Cloud Structured Query Language) was created which improved the performance and scalability. The new or old data stored in SQL could be accessed through the internet anywhere in the world. As a result, the method obtained for users and CS avoided congestion and reduced energy consumption. On the other hand, it slowed down the operation because the communication of the grid operator was not done. Li et al. (2021) illustrated that IoT was a network connection with a different number of nodes using a Space Fault Network (SFN). SFN proved that the reliability change of IoT is parallel to SFEP (System Fault Evolution Process). The processes and interactions of IoT were equivalent to the SFN network structure. SFN could be expressed in matrix form. The different network structures are obtained which are considered TEPAM and TEPCM. The structure representation of SFN is shown and the research had been done independently. Goudarzi et al. (2019) discussed the efficiency of IoT in various wireless networks. The Markov decision process was generated which expressed the issues present in vertical handoff (VHO). The hybrid model merged with BBO (Biogeography-based Optimization) with the Markov decision process (MDP). Radio access technology (RAT) was developed by MDP. RAT was obtained as input to the BBO process. As a result, the MDP-BBO algorithm obtained a better reward and the average account of handoffs was reduced. Meanwhile, it was low flexibility and the cost was high.

Research methodology

This paper analyzes landslide monitoring data sharing and interoperability from the data model thereby providing a reference for the standardization of geological disaster data sharing and interoperability. The steps involved in our proposed study are depicted in the following section.

SensorThings entity-relationship model

The basis of the SensorThings API is to model the relationship between the entities in the system in the real world. The natural relationship between these entities allows IoT sensor devices in any vertical industry to be modeled. The basis of the SensorThings API is to model the relationship between the entities in the system in the real world. The natural relationship between these entities allows IoT sensor devices in any vertical industry to be modeled. For example, an IoT device or an IoT system can be modeled as an object (Thing), and an object (Thing) contains both a location (Location) and one or more data streams (Datastreams). Each data stream (Datastream) is obtained through a sensor (Sensor) observing an observation property (ObservedProperty), and this sensor (Sensor) may have multiple observations (Observations). The sensor (Sensor) observes (Observation) is a specific observed object (FeatureOfInterest). In summary, these interrelationships can be used to describe and simulate various sensor systems flexibly and standard. The flow diagram based on the SensorThing entity-relationship model is

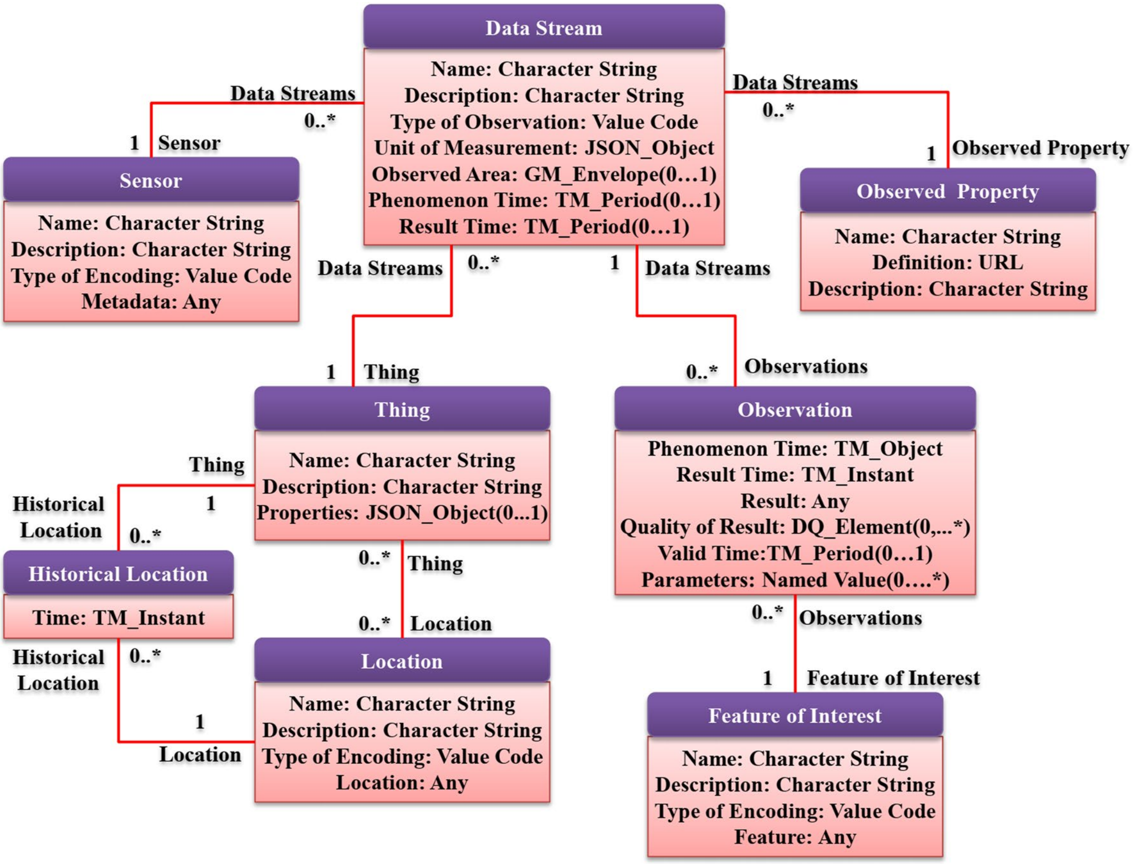

Fig. 1 SensorThing entity-relationship model

depicted in Fig. 1 (https://ogc-iot.github.io/ogc-iot-api/img/SensorThingsUML_Core.svg).

Landslide monitoring information sharing based on OGC SensorThings

The OGC SensorThings are utilized in the monitoring process that provides a geospatial unified connection that implements various applications in the IoT network. It is determined with significant functionalities and they are handled individually by addressing the syntactic as well as semantic interoperability of IoT.

Geological disaster landslide monitoring data model

Numerous geological forces affect the earth's surface and rock layers but some factors maintain their original state in the formation process. The main reason for the formation of disaster is vibration and displacement. Therefore, this article will take vibration, displacement, rainfall, and groundwater as examples to build an IoT monitoring data model for OGC SensorThings shared services (Khan et al. 2021).

According to the physical model in Fig. 1 and the specific content of landslide monitoring in Table 1, the data model for OGC SensorThing Internet of Things shared service as shown in Fig. 2 below is designed as follows.

Table 2 depicts the relational tables for various disaster management processes (Dachyar and Nilasari 2020).

As shown in the figure, in the landslide monitoring system, equipment is the starting point of the system, and one piece of equipment is in one position at a certain moment. According to the OGC SensorThing model, observation refers to a collection of the same observation attributes measured by a sensor to form a data stream, and each observation produces an observation result. According to different sensors and observation attributes, a device can contain multiple types of data streams (observation sets). It is particularly important to note that the type of observation result is not defined in the observation attribute, but the observation type defined in data streams, which is included in this system (displacement, vibration value, precipitation, groundwater level, groundwater volume, etc.). According to this model, a database containing the following relational tables can be built. The specific fields will not be explained in this article.

Table 1 Entity and monitoring the content of landslide monitoring Internet of Things

Thing	Sensor	Observed property	Description	Features of interest
Fixed inclinometer	Fixed inclinometer sensor	Plane displacement monitoring Vertical displacement	Validate the small movement by determining specific land subsidence monitoring process	The location of the device
Buried Stone Sensor	Buried Stone Sensor	Amount of vibration	Fracture monitoring is determined to monitor subsidence and velocity variations in the slope	The location of the device
Automatic rain gauge	Automatic rain gauge	Rainfall	Monitor the amount of rainfall in a specific area	Target area (range) monitored by automatic rain gauge
Water level sensor	Water level sensor	Groundwater level	Groundwater level water volume data	The location of the device

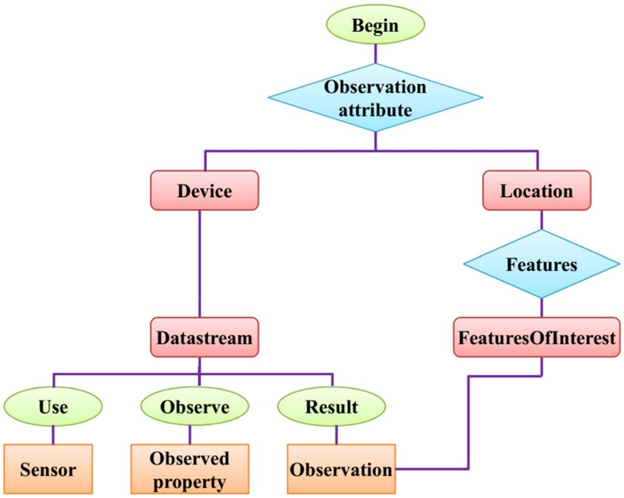

Fig. 2 Entity relationship diagram of the data model of a landslide monitoring system for OGC SensorThing

Geological disaster landslide monitoring information service API for OGC SensorThings

The OGC SensorThings standard defines an API for providing a unified connection, which can implement operations such as query, addition, modification, and deletion of Internet of Things devices and observation data. These operation modes are provided in the way of the RestAPI interface. According to the OGC standard, for the geological disaster-oriented landslide monitoring information service, the following observation data observation and query service interfaces are provided in Table 3.

Take the query device as an example. The following request is used to query the device with the specified id, and the returned content is in json format.

Service example 1:

Use id to query the device by connecting to https***://host_address/v1.0/Things(id).

Table 2 Relational Tables

Relational tables	Explanation
tb_device	Contains a primary key field of the tb_location table, indicating the most recently observed location
tb_datastream	Contains the primary keys of the three tables tb_sensor, tb_observedProperty, and tb_observation as fields
tb_device_datastream	Contains the primary keys of tb_device and tb_datastream
tb_sensor	
tb_observedProperty	Contains the description fields of the observations defined in OGC SensorThing (including name, definition, and description)
tb_Observation	Contains the field of observation time, observation value, and observation quality defined by OGC SensorThing
tb_Location	Location entity table
tb_historical_location	Contains the primary keys of the tb_device table and the tb_location table as fields, and an observation time
tb_FeaturesOfInterest	The observation feature is the location of the equipment in this system,

Table 3 Description of various service providers

Provide services	Operation object	Request operation	Request method	Return format
Query device	Device	Get	http	Json
Query device location	Device Location, Device Historical Location	Get	http	Json
Query the data stream that is the content of the observation (Datastream)	Data Stream	Get	http	Json
Query sensor	Sensor	Get	http	Json
Query observation attributes	Observation attribute description	Get	Http	Json
Query observation results	Observation result	Get	http	Json
Comprehensive filter query	Integrated Query	Get	http	Json

The returned result example is as follows:

```
{
        "@iot.id": 1
        "@iot.selfLink": "https://host_address/v1.0/Things(1",
        "description": "Fixed inclinometer, which can be used for automatic monitoring of
        displacement"
        "name": " Fixed inclinometer,",
        "properties": { },
        "Datastreams@iot.navigationLink": " https://host_address/v1.0/Things(1/Datastreams",
        "HistoricalLocations@iot.navigationLink":"https://host_address/v1.0/Things(1/Historica
        lLocations",
        "Locations@iot.navigationLink": " https://host_address/v1.0/Things(1/Locations"
        }
```

Same as the OGC FES (Filter encoding standard) and SQL, OGC SensorThings API also provides two types of query operation options, among which $expand and $select are used to specify the returned attributes; $orderby, $top, $skip, $count and $filter is used to limit, filter or reorder the returned results. The following examples show two kinds of query examples, where $expand is used to query a collection of specified related entities, and $selec is used to return the specific attributes of an entity requested from a specified service, reducing the amount of data transmission.

```
{
        https://host_address/v1.0/Things?$expand=Datastreams
        "https://host_address/v1.0/Observations?$select=result,phenomenonTime"
}
```

According to the attribute value, it can be realized by using the query condition to use the $filter. The OGC SensorThings standard defines built-in operation operations such as comparison operations, logical operations, group operations and string operations, date, mathematics, geospatial functions, spatial relationship functions, and other filtering The query function supports various condition filtering requirements.

The filtering of the spatial conditions uses the SQL spatial relation operation function defined in the OGC SFS (OpenGIS Simple Features Interface Standard) standard. The following example shows the query polygon POLYGON ((30 10, 10 20, 20 40, 40 40, 30 10)). The location entity within the range.

```
{
    "/v1.0/Locations?$filter = st_within (location, geography'POLYGON ((30 10,
10 20, 20 40, 40 40, 30 10))')"
}
```

Design and analysis of shared service system

Concerning the implementation of the WebGIS geographic information application, this paper designs a landslide monitoring shared service support system based on the OGC SensorThings API standard. Its system structure is delineated in Fig. 3.

As shown in the figure, different from other IoT platforms, this platform provides space services based on OGC standards and IOT monitoring information services to support standardized sharing and interoperability of landslide monitoring data.

Providing Web application servers that support standard interface services is an important support condition for providing geospatial information-sharing services. In the WebGIS field, whether it is commercial WebGIS servers such as ArcGIS Server, SuperMap, or open source GeoServer and MapServer servers, they all provide good support for OGC Web service standards. At the same time, the commercial software also provides a well-packaged front-end development interface kit for accessing OGC Web services.

The open-source front-end WebGIS development components OpenLayers and Leaflet also encapsulate the access and operation of OGC Web services, providing developers with a convenient development platform.

Compared with geospatial data sharing services, including Web Feature Service (WFS), Web Map Service (WMS, Web Map Service), Web Map Tiled Service (WMTS, Web

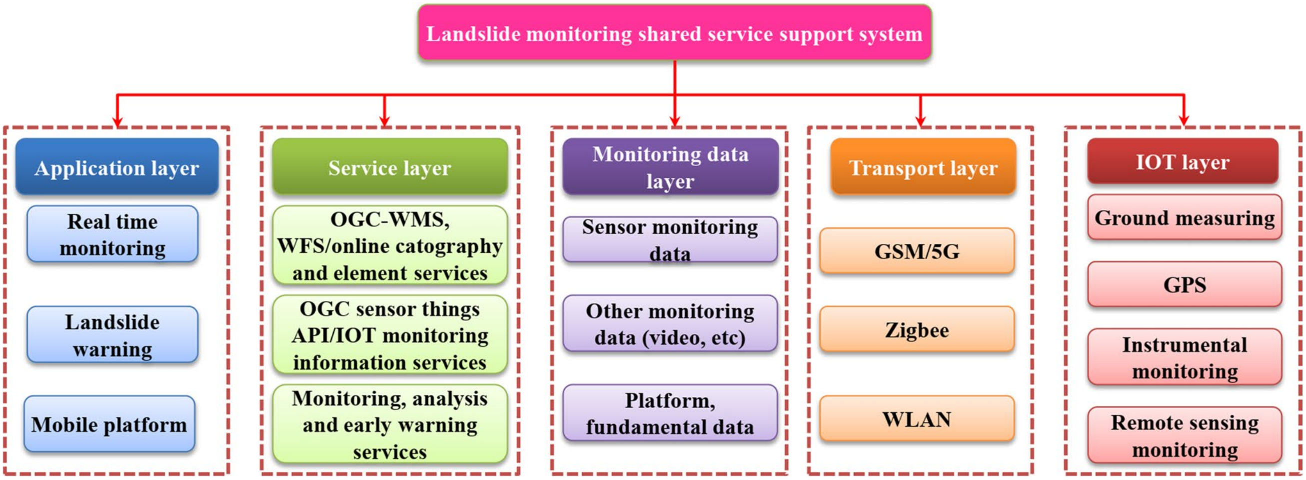

Fig. 3 The architecture of landslide monitoring shared service support system based on the OGC SensorThings API standard

Map Tiled Service), and Internet Coverage services (Web Coverage Service), etc., whether it is the OGC organization in terms of standard designation or the support of WebGIS server vendors for standard services, the standardization of IoT monitoring information sharing is still under continuous development. The OGC SensorThings standard is the latest achievement of the OGC organization in IOT. On the commercial platform, currently, only the SensorUP Internet of Things service platform claims to have passed the OGC certification in 2018 and meets the OGC and ISO standards of IoT. For open source software, only FROST-Server implements the SensorThings API standard, and its underlying spatial database uses PostGIS spatial database, which is not yet very mature.

Results and key findings

This section provides the evaluation analysis based on various parameters namely computational cost, power utilization, fitness function, danger rate, evacuation time, total travel time as well as root mean square error.

Experimental setup

The efficiency of monitoring disaster management is processed in the ADXL355 sensor by presenting water level filtration.

Dataset description

In order to determine the severity level of disaster management publicly available sources are employed for generating the overlapping sequence of training and testing processes.

AIDR Disaster type dataset (AIDR-DT)

In this dataset, the tweets are gathered from the AIDR system containing 17 disaster events and 3 general collections. It is employed for floods, earthquakes, hurricanes, fires, etc. These are determined with a keyword natural disaster and their severity level is predicted based on their types (https://roc-hci.github.io/NADBenchmarks/). To perform the validation a sample of 200 images is selected to categorize the type of disaster. The images are gathered from different sources and filtered the duplicate samples. With the remaining samples, the presence of natural disasters is tested.

Damage multimodal dataset (DMD)

The dataset is obtained with 5878 sample images with more than 100 hashtags. It is employed with six damage class labels flood, fire, hurricane, landslide, etc. (https://archive.ics.uci.edu/ml/datasets/Multimodal+Damage+Identification+for+Humanitarian+Computing). It validates the damaged and non-damaged portions which are not relevant or useful for humanitarian tasks. The gathered images are relabelled based on their disaster type and estimate the total damaged classes.

Table 4 Dataset description for geological disaster management

Dataset	Classes	Total	Training	Testing
AIDR-DT	Hurricane	1609	1287	322
	Landslide	1277	1022	255
	Flood	2833	2266	567
	Fire	1309	1047	262
	Earthquake	2487	1990	497
	Not disaster	2120	1696	424
	Another disaster	88	70	18
DMD	Fire	362	290	72
	Earthquake	182	146	36
	Hurricane	362	290	72
	Landslide	54	43	11
	Flood	368	294	74
	Not disaster	2971	2377	594
	Another disaster	1489	1191	298

Table 4 depicts the various disaster-type classes with training and testing ratios.

Comparative analysis

Figure 4 depicts the graphical representation to determine the cost of various 5G communication systems of IoT employed in disaster management namely the Bluetooth, WiFi, LoRa, Zigbee, Z-wave, NB-IoT as well as 2G/3G systems. The disaster cost considerably varies based on various range aspects, particularly the geographical location where they occur. Here the graphical analysis is plotted for three different types of risks namely the high risk, medium risk, and low risk. From the graphical analysis, it is seen that Bluetooth and WiFi are at minimum risk; LoRa, Zigbee, and Z-wave are at medium risk phase and NB-IoT, as well as 2G/3G system, are at high-risk phase.

In Fig. 5, the power utilization for various 5G communication systems of IoT employed in disaster management namely the Bluetooth, WiFi, LoRa, Zigbee, Z-wave, NB-IoT as well as 2G/3G system is computed. Minimum power utilization provides high system efficiency. Similar to the above-mentioned graph, various IoT systems are split into three different types of risk categories namely high risk, medium risk, and low risk. From the graphical analysis, it is demonstrated that Bluetooth LoRa, and Zigbee, are at minimum

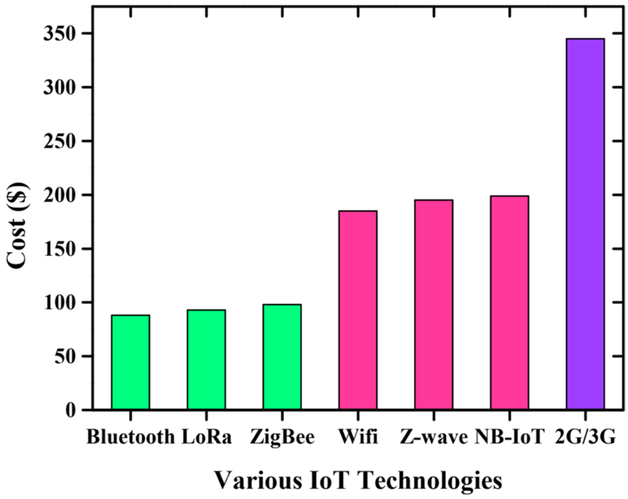

Fig. 4 Cost computation of various IoT systems

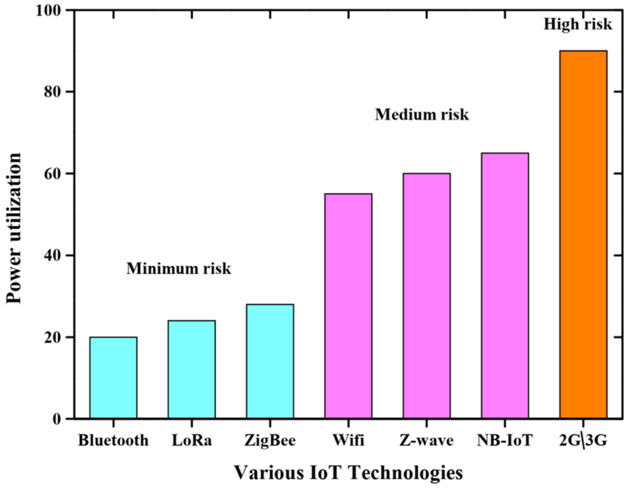

Fig. 5 Power utilization analysis of various IoT systems

risk; WiFi, Z-wave, and NB-IoT are at medium risk phase as well as 2G/3G systems are at high-risk phase.

Figure 6 depicts the graphical analysis to determine the fitness value concerning the total number of iterations (i.e. 10, 20,…100). Fitness function in other words refers to the evaluation function that determines how close the provided solution reaches the optimal solution for a particular problem. From the graphical analysis, the fitness value attained for the proposed approach is higher which provides better system efficiency. The proposed technique convergences over time and provides a better result.

In Fig. 7, the graphical representation to determine the danger rate based on different types of risks namely the very high risk, high risk, medium risk, low risk, and very low risk are plotted for the proposed land-side disaster management system. The range of very low-risk and low-risk phases is between 0 to 15. The medium risk value ranges between 15 to 20 and the range of very high risk and high risk phase are between 20 to 25.

Figure 8 depicts the graphical representation to determine the evacuation time analysis for the proposed work. The final vehicle after a landslide to reach the particular area after the completion of evacuation. The graphical analysis is plotted for various works and from the experimentation result, it is demonstrated that the proposed approach attained minimum evacuation time than various other existing works.

The evaluation based on the total travel time is plotted in Fig. 9. The term total travel time is defined as the total time of all vehicles after the evacuation process. The graph is plotted between the proposed work and various works. From the experimentation result, it is seen that the proposed approach attained a minimum total travel time than various other existing works.

Figure 10 depicts the graphical representation to determine the Root Mean Square Error (RMSE) analysis. Minimum root mean square error enhances the performance of the system. The RMSE is widely utilized to validate the quality of the prediction process in disaster management systems. It validates the quality of sharing information regarding various applications. Large error values determined in the validation are predicted and it is lowered to perform an effective communication. The higher RMSE value diminished the performance of the model and the lower range maximized the effectiveness with low error generation. The graphical analysis is plotted for various works and from the experimentation result, it is demonstrated that the proposed approach attained minimum root mean square error than various other existing works.

Figure 11 depicts the cost analysis of various existing and proposed methods. The validation of cost determines the efficiency of the model. The reduction of cost showed an improved performance with better communication for sharing the disaster management process. In this, the comparison is performed with the existing ANN, MDP, SFN, NFC, and proposed methods. The proposed diminished the cost by 49 than other techniques.

The validation of cost with respect to time is delineated in Fig. 12. Based on the amount of cost the performance of the model is estimated and also the time is minimized regarding the expense. The outcome determined that the proposed method attained 51 and the other existing methods such as ANN, MDP, SFN as well as NFC achieved 68, 56, 61, and 54, respectively.

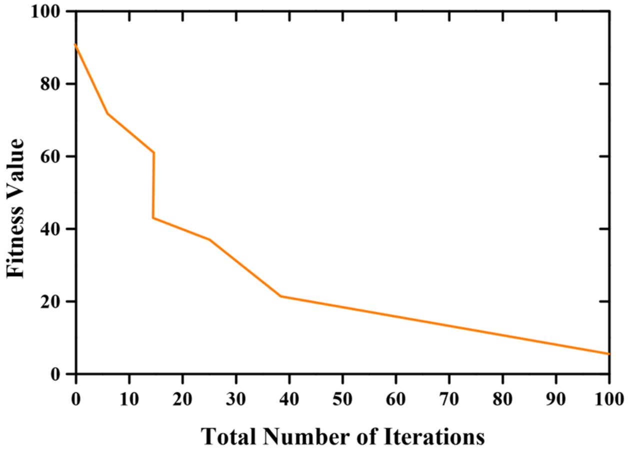

Fig. 6 Fitness function analysis

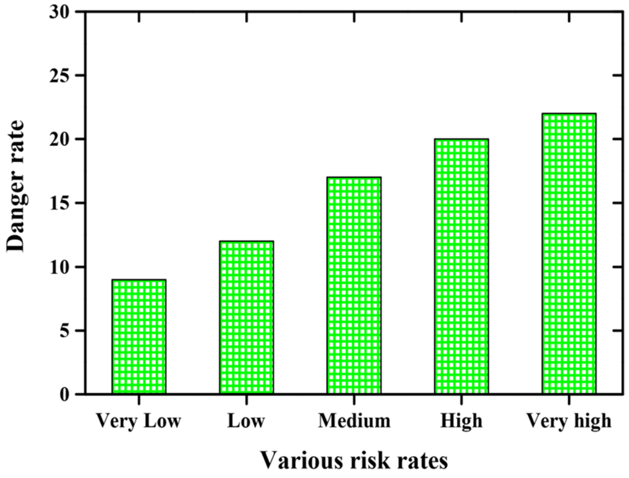

Fig. 7 Danger rate analysis

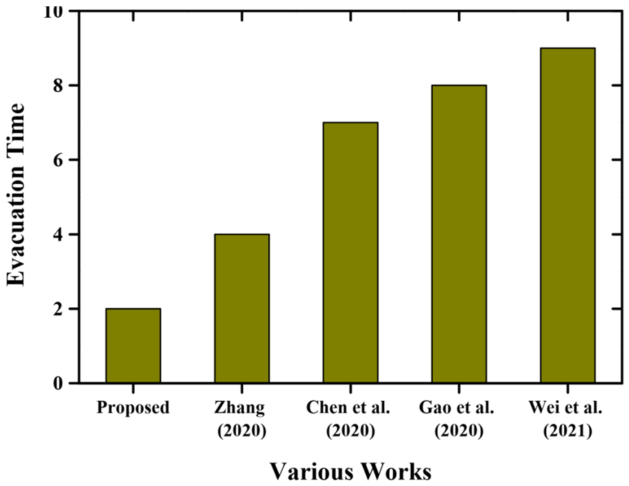

Fig. 8 Evacuation time analysis

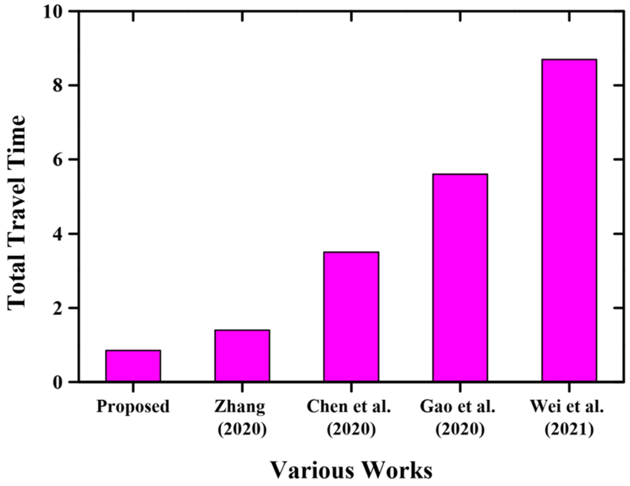

Fig. 9 Total travel time evaluation

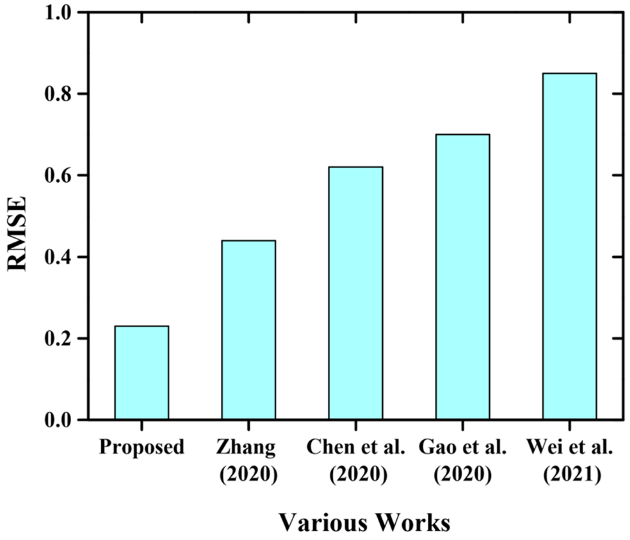

Fig. 10 Root Mean square error analysis

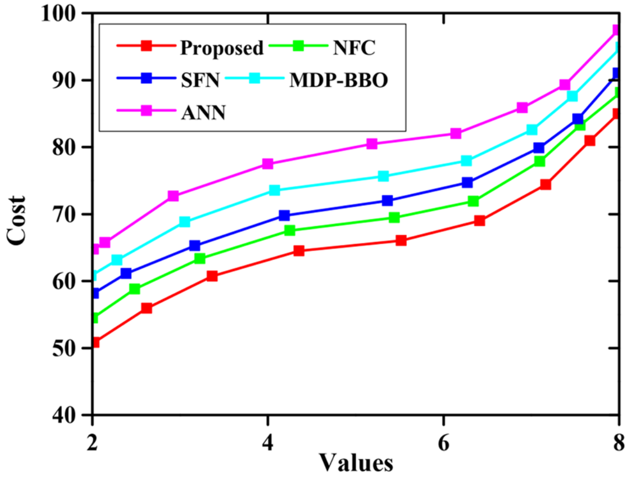

Fig. 11 Validation of cost

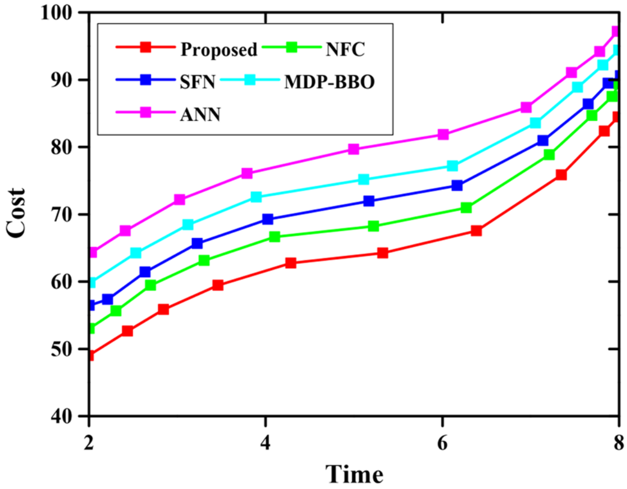

Fig. 12 Cost analysis with time

Discussion

The disaster monitoring process is significant to protect humans and their lives by sharing information immediately through the IoT network. The IoT network is used to detect landslide disasters at low cost and it contains mature technological applications. To perform an efficient information sharing process the OGC SensorThing application is employed. It is determined with numerous efficient characteristics applications that monitor the interoperability and data sharing process in IoT. ZigBee is a multisensory and wireless mesh network that collects the features and provides alert warnings to people regarding the disaster. Multiple geological data are gathered at a time through SensorThing and validate the efficiency of the data sharing process by cost, power utilization, fitness evaluation, evacuation as well as total travel time and RMSE. However, the cost and utilization time are diminished with a minimum error rate that improves the effectiveness of the model. But it does not provide efficient security for the objects utilized to share information.

Conclusion

The information regarding disaster management is provided with IoT devices that generate alert signals to safeguard the properties. In heavy load conditions, the transmission is not performed correctly and there is a loss of data while performing communication. Hence OGC's geographic information standards are widely used in geographic information-sharing services. In the field of geological data standards, 6eoSciML (6eoScience Markup Language) is a general geological markup language developed based on GML for geological data exchange and interoperability. In the field of geological data standardization, the GeoSciML standard covers multi-source, multi-type, and multi-dimensional geological data such as regional physical exploration, remote sensing, and geochemical exploration data. Based on the OGC Sensor Thing API standard, this article conducts an in-depth study on landslide monitoring data sharing and interoperability from data models, shared service content, and system construction. The interoperability is utilized to transfer the information among various systems in the same language and preserve the incoming data in the original text format. It is a CGI and IUGS standard exchange format that is consistent with the OGC standard. IoT applications are an important part and extension of geospatial applications. The results show that the OGC SensorThings standard provides a rich and complete operation interface for the information sharing and interoperability of disaster monitoring systems. The evaluation analysis is based on various parameters namely computational cost, power utilization, fitness function, danger rate, evacuation time, total travel time as well as root mean square error. The OGC SensorThings API standard is processed in various applications and implemented uniquely. It can handle numerous applications at a time in the process of sharing information regarding monitoring disaster management. This model is highly beneficial and processed effectively by diminishing time and error as well as the validation of the fitness function shows the effectiveness of the method. However, to promote the information sharing and interoperability of disaster monitoring systems, the industry still needs to further strengthen the protection of objects that meet the OGC SensorThings API standard.

Author contributions GZ, XL, FZ, YS and GL agreed on the content of the study. GZ, XL, FZ, YS and GL collected all the data for analysis. GZ agreed on the methodology. GZ, XL, FZ, YS and GL completed the analysis based on agreed steps. Results and conclusions are discussed and written together. The authors read and approved the final manuscript.

Funding Not applicable.

Availability of data and materials The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declarations

Competing interests The authors declare no competing interests.

Conflict of interest The authors declare that they have no conflict of interest.

Human and animal rights This article does not contain any studies with human or animal subjects performed by any of the authors.

Informed consent Informed consent was obtained from all individual participants included in the study.

Consent to participate Not applicable.

Consent for publication Not applicable.

References

Chen G, Li S (2020) Research on location fusion of spatial geological disaster based on fuzzy SVM. Comput Commun 153:538–544

Chen C, Hui Q, Xie W, Wan S, Zhou Y, Pei Q (2021) Convolutional Neural Networks for forecasting flood process in Internet-of-Things enabled smart city. Comput Netw 186:107744

Dachyar M, Nilasari T (2020) The improvement of disaster relief distribution by accommodating Internet of Things (Iot) real-time data. Int J Adv Sci Technol 29(7):3654–3664

Durrani TS, Wang W, Forbes SM (2019) Geological disaster monitoring based on sensor networks. Springer

Gao X, Wu G, Chen J, Zeng Q (2020) Design and implementation of geological hazard monitoring system via the Internet of Things. Arab J Geosci 13(21):1–7

Goudarzi S, Anisi MH, Abdullah AH, Lloret J, Soleymani SA, Hassan WH (2019) A hybrid intelligent model for network selection in the industrial Internet of Things. Appl Soft Comput 74:529–546

Kaur A, Sood SK (2020) Cloud-Fog based framework for drought prediction and forecasting using artificial neural network and genetic algorithm. J Exp Theor Artif Intell 32(2):273–289

Khan R, Yousaf S, Haseeb A, Uddin MI (2021) Exploring a design of landslide monitoring system. Complexity. https://doi.org/10.1155/2021/5552417

Li S, Cui T, Alam M (2021) Reliability analysis of the Internet of Things using Space Fault Network. Alex Eng J 60(1):1259–1270

Liu Y, Dhakal S (2020) Internet of Things technology in mineral remote sensing monitoring. Int J Circuit Theory Appl 48(12):2065–2077

Salam A (2020) Internet of Things for sustainability: perspectives in privacy, cybersecurity, and future trends. Internet of Things for sustainable community development. Springer, pp 299–327

Savari GF, Krishnasamy V, Sathik J, Ali ZM, Aleem SHA (2020) Internet of Things-based real-time electric vehicle load forecasting and charging station recommendation. ISA Trans 97:431–447

Sinha BB, Dhanalakshmi R (2022) Recent advancements and challenges of Internet of Things in smart agriculture: a survey. Futur Gener Comput Syst 126:169–184

Wei T, Feng W, Chen Y, Wang CX, Ge N, Lu J (2021) Hybrid satellite-terrestrial communication networks for the maritime Internet of Things: key technologies, opportunities, and challenges. IEEE Internet Things J 8(11):8910–8934

Yang L, Li D, Zhao J, Tang J, Qiu Y, Lu J (2019) Development of digital mine information platform based on Internet of things technology. In: 2019 IEEE International Conference on Computation, Communication and Engineering (ICCCE), pp 91–94

Zhang W (2020) Geological disaster monitoring and early warning system based on big data analysis. Arab J Geosci 13(18):1–9

Zhu Z, Bai Y, Dai W, Liu D, Hu Y (2021) Quality of e-commerce agricultural products and the safety of the ecological environment of the origin based on 5G Internet of Things technology. Environ Technol Innov 22:101462

Zhuang L, He J, Yong Z, Deng X, Xu D (2020) Disaster information acquisition by residents of China's earthquake-stricken areas. Int J Disaster Risk Reduct 51:101908