Desalination and Water Treatment
www.deswater.com

doi: 10.5004/dwt.2021.27577

241 (2021) 304–309
November

The use of mountain torrent disaster model under multisource data fusion

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Received 29 June 2021; Accepted 23 September 2021

ABSTRACT

The purpose is to get the disaster data in real-time and accurately, conduct correlation analysis, and scientific supervision and guidance of disaster situations and reduce the loss of people's life and property safety caused by natural disasters. The data relating to large floods and geological disasters in the past are evaluated. With the assistance of the big data platform, BeiDou Navigation Satellite System, related equipment and artificial intelligence technology, the light version of natural disaster big data platforms such as floods have been constructed, which greatly reduces the monitoring points and operation and maintenance costs. The disaster data association analysis platform is connected with the manual command and decision-making system to provide the basis for prediction, decision-making and command.

Keywords: Disaster investigation; Mountain torrent disaster model; Data fusion; Association analysis

1. Introduction

Flood, landslide, debris flow and other natural disasters caused by precipitation have existed for a long time in China. The prevention of these natural disasters is a crucial means of disaster prevention and reduction, which includes the monitoring and analysis of river flow, the evaluation of soil porosity and the detection and analysis of meteorological conditions [1]. However, in the actual work, there are some problems, such as difficult work implementation, imperfect facilities in most places, relatively independent information [2], low capacity of emergency monitoring equipment, insufficient emergency monitoring means and so on [3]. Hence, how to real-time monitor the meteorological, hydrological and other information and make correlation analysis [4] to realize the unified management of each monitoring point is of great significance to the investigation and emergency management of mountain torrent disaster.

A 3D grid is constructed, with the help of unmanned mobile monitoring equipment, to collect real-time data for joint analysis and simulate the disaster data model. Besides, based on the needs of data integration and storage, disaster data are integrated to connect with the provincial hydrological and meteorological data to build an open and safe meteorological warning platform for mountain torrents. The research innovation is to use computer technology to collect disaster data, greatly reducing the investment of hardware facilities [5]. This exploration has a certain reference value for the research of disaster prevention and reduction.

2. Data perception and fusion strategy of flood and geological disasters

A 3D grid is built to realize the data perception and fusion of flood and geological disasters. With the help of unmanned mobile monitoring equipment, fixed monitoring stations at key locations, and inspectors, real-time and accurate data are collected for joint analysis to simulate the disaster data model. Fig. 1 shows the architecture of fusion aware computer system.

Fig. 1 presents that the architecture of fusion perception system includes six modules, and each module is complementary to form a perfect fusion perception system, laying the foundation for further data analysis and visualization display [6]. The main function of multisource data acquisition normalization module is to classify the data from multiple sources into serializable data structure and configure different schemes for the data; the function of geographic information base network module is to use GIS technology to build geographic information base of different models [7], which is convenient to read and analyze; the comprehensive perception module can establish the corresponding description model of the classified flood and geological disaster information data, extract the core data features and implement the deduction; the tensor calculation framework module provides optimization calculation according to different neural network model algorithms to improve the iteration efficiency of the model; the model expression module can realize the 3D information expression, generate the comprehensive display template of flood, debris flow and landslide, and build the early warning model of mountain flood and water regime [8]; the artificial intelligence module performs intelligent data analysis, data evaluation, water conservancy factor algorithm prediction and result reliability analysis for the whole modeling process and real-time data prediction process of water conservancy model to reduce the decision-making risk of decision-makers.

3. Experimental scheme design

3.1. Multisource data fusion component

With the assistance of computer and internet technology, the data obtained from satellite remote sensing, unmanned aerial vehicle (UAV), unmanned ship surveying and mapping, underwater robot and detection equipment at various stations are collected and fused to form a set of space-sky-ground 3D grid system [9]. The “space” is to use the data provided by various satellites to discover the possibility of problems. “Sky” mainly is to uses UAV remote sensing to provide the most timely, reliable and professional high-resolution image. “Ground” is to achieve fine comprehensive monitoring by various monitoring means on the ground [10].

The light big data management mode based on the obtained data can realize the rapid and simple construction of the data platform, as shown in Fig. 2.

Fig. 2 suggests that the big data platform consists of four parts, namely real-time data monitoring, system data

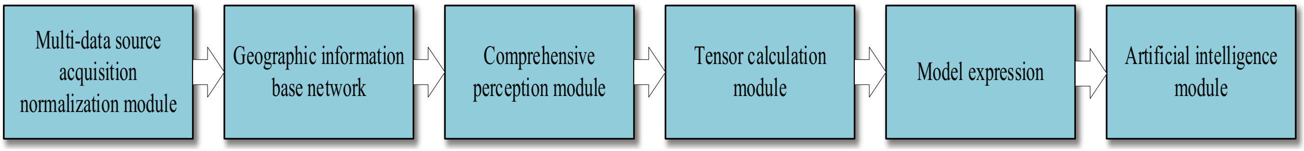

Fig. 1. The architecture of fusion perception computing system.

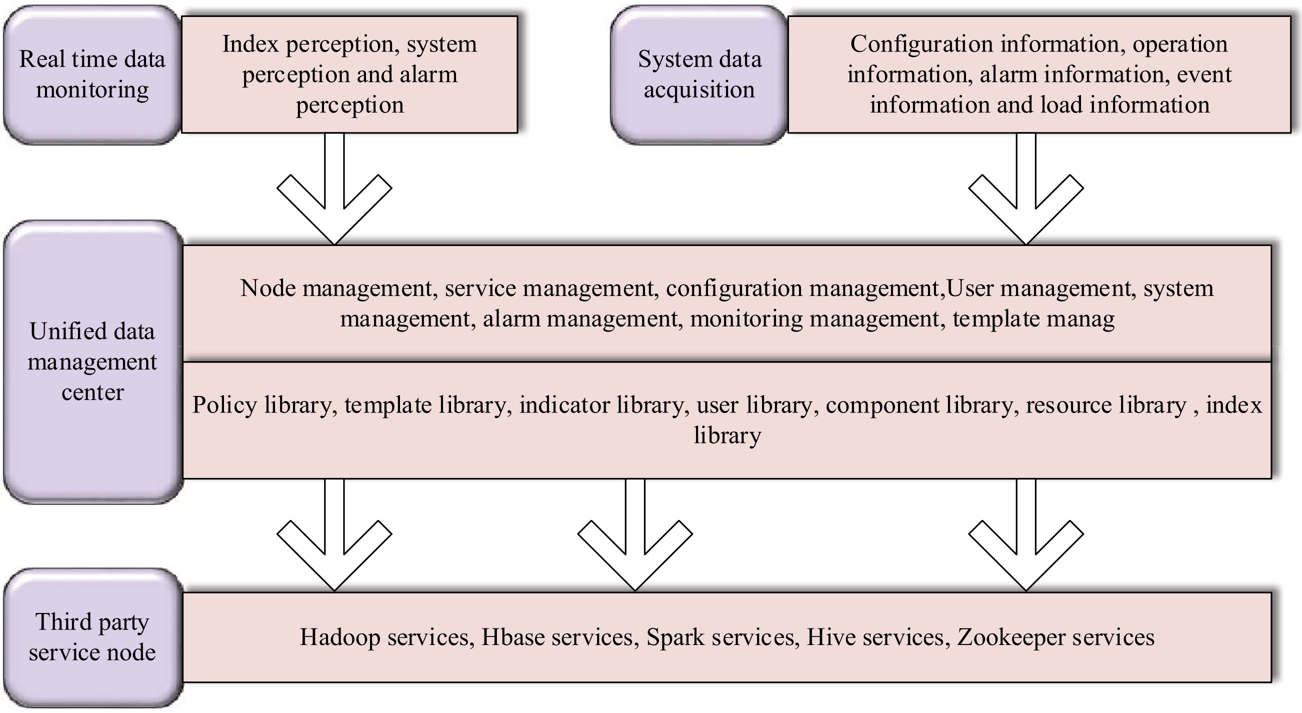

Fig. 2. The architecture of big data platform.

collection, unified data management center and third-party service node. Based on the requirements of data integration, storage, service, application, security and management, disaster data are integrated and connected with provincial hydrological and meteorological data to build an open and safe meteorological warning platform for mountain torrent disasters [11,12].

3.2. Data analysis engine and algorithm model

The virtual monitoring data is formed through numerical calculation, and the statistical prediction model of water level, flow rate, flow rate and other data is constructed by using entropy method, hot spot technology, and machine algorithm. Moreover, the multisource data verification is realized to help to greatly reduce the monitoring points and operation and maintenance costs [13].

Based on the land air coupling model, the precipitation-basin hydrological model of numerical atmospheric simulation is adopted for flood forecast [14]. The real-time meteorological observation and cloud analysis are conducted by meteorological satellites to simulate and forecast the precipitation. With the assistance of cloud big data technology, the weather research and forecasting model (WRF) is employed to forecast the hourly rainfall and rainfall distribution in 7 d [15]. Since WRF is a mesoscale numerical atmospheric model, 3D variational (3DVar) technology is used to assimilate multisource meteorological data in real-time, so as to obtain more accurate rainfall forecast results, and make the background field closer to the actual climate situation. The weather forecast model of the WRF-3DVar model is formed by using weather radar data and data from the global telecommunication system [16].

Fig. 3 shows the framework of the forecasting model.

Fig. 3 shows that the rain flood forecasting technology includes meteorological data, flood model, model correction and other parts. The autoregressive moving average model is used for real-time correction and automatic intelligent forecasting of the basin through the results of WRF and WRF-3DVar forecasting, along with the coupled hydrological model [17].

Flood disaster early warning and forecasting model is based on big data to process and analyze hydrometeorological related data. According to natural conditions such as flood disaster, different data form hydrometeorological data to meet the needs of early warning data analysis [18]. Meanwhile, artificial intelligence technology is employed to further check the data information and calibrate the model.

Through the integration technology of meteorological and hydrological observation data, the intelligent real-time forecasting hydrological model driven by big data is established, based on the big data-driven runoff generation and concentration simulation theory and big data support hydrological model. The proposed model improves the accuracy of mountain torrent disaster forecasting. Meanwhile, the real-time monitoring module is set [19] and combined with artificial intelligence and cloud computing technology. Water level monitoring sensors are added to collect atmospheric change data in time.

Debris flow disaster monitoring model is based on debris flow data analysis. The general construction and control projects cannot effectively deal with the debris flow disasters because of their unpredictable nature [20], which leads to the frequent occurrence of debris flow [21]. The following measures can provide decision support for the geological disaster monitoring department and reduce the loss of life and property: (1) monitoring the change of material sources in the mud and stone basin; (2) making hazard assessment for debris flow disaster after material source change; (3) predicting accumulation range, predicting hazard range; (4) evaluating the prevention and control engineering capability in the area; (5) establishing the debris flow disaster monitoring model based on the prediction of rainfall.

The research process from data, information to target results mainly depends on the data analysis platform. Data analysis can combine output theory, industry experience and computer tools perfectly. The historical data and real-time monitoring data collected from the research area are the main data sources of the back-end data analysis system platform. The task of the data analysis system platform is to preprocess the data first, and then use the traditional hydrological analysis method, along with a machine learning algorithm, to build statistical prediction models to predict the water level, flow and other target values in the river basin.

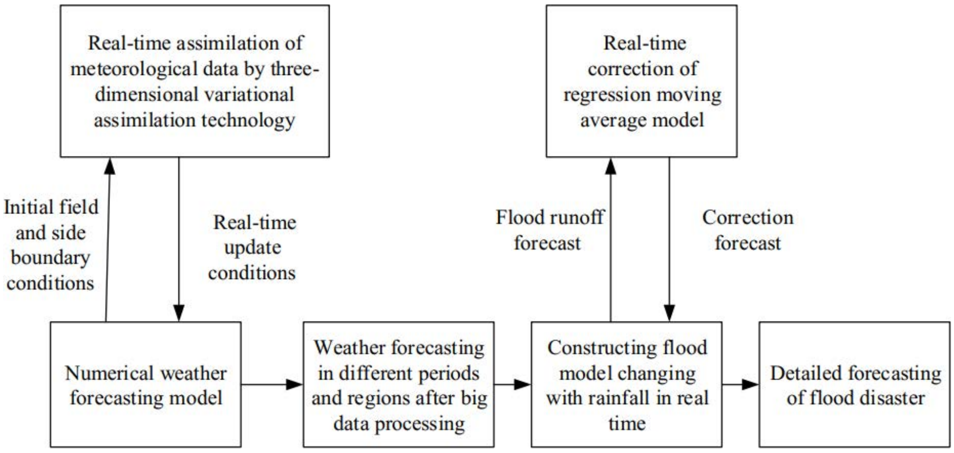

Fig. 3. Rain flood forecast framework.

3.3. Artificial intelligence analysis

The water conservancy model is based on the once-in-a-decade water regime data and combined with the real-time data to simulate the water environment, so as to achieve the real-time water regime prediction and early warning of water conservancy disasters. The following core problems have emerged as the development of water conservancy model technology in recent years [22]. (1) How to improve the accuracy of the water conservancy model in real-time? (2) How to make the model respond quickly to the data beyond the estimated range? (3) How to make the model automatically adjust and process data. Based on the traditional water conservancy model, the application of mountain torrent disaster statistical analysis, along with artificial intelligence algorithm, provides technology breakthrough in application level for the model from data input to the final prediction result output. In the whole modeling process and real-time data prediction process of the water conservancy model, the intelligent data analysis, water conservancy factor algorithm prediction, results reliability analysis are conducted to reduce the decision-making risk of decision-makers, improve the governance ability of water conservancy disasters, and extend the effective prediction period of water regime forecast.

In recent years, the research of artificial intelligence and mountain torrent disaster technology has become increasingly complete, mainly focusing on these aspects. Based on machine learning and deep learning technology, the research and exploratory application in rainfall forecast, flood calculation model parameters, flood forecast and early warning and flood disaster risk assessment are carried out; regarding the problem of high-resolution data classification, a series of key algorithms for remote sensing image and laser point cloud classification and change spot detection based on deep learning are developed, which greatly improves the classification accuracy of remote sensing image and laser point cloud; for the problem of parameter regionalization of small watershed without data, a method of parameter regionalization of small watershed based on machine learning is developed based on basic attribute dataset, underlying surface parameter dataset and soil texture dataset.

3.4. Experimental area and tool selection

Because of the large mountain area in Southwest China, which is prone to flash flood disaster, Southwest China is selected as the main study area.

CL-4 fixed-wing long-endurance UAV system is employed to collect disaster information. The system consists of the UAV platform, transportation and support shelter and command and control vehicle. Fig. 4 shows the UAV platform.

Fig. 4 shows that the UAV platform has various load carrying capabilities, which can cooperate with ground command and control vehicles to realize the rapid perception of wide-area disaster environment information. It can be combined with the subsequent transportation and support shelter to complete the UAV system transition and field assembly and maintenance. The command and control vehicle can realize the UAV command and scheduling, flight control, flight monitoring, mission planning, load control and other functions.

Fig. 5 shows the selection of the measuring instrument.

Fig. 5 shows the Sony Alpha 7R IV 61-megapixel digital camera and Haida digital cloud "Zhihui" airborne lidar radar. The aerial digital camera is used to capture aerial image data. The high-resolution digital camera is used to obtain the true color or infrared digital image information of ground features and landforms. After correction and mosaic, the color orthophoto digital image can be formed, and the target can be classified and recognized. Airborne lidar radar is the abbreviation of laser detection and

Fig. 5. Measuring instruments (Sony A7R4 Camera on the left, Haida digital cloud "Zhihui" airborne lidar radar on the right).

Fig. 4. CL-4 small endurance UAV platform.

ranging system. Airborne lidar radar measurement system is a kind of active aerial remote sensing device. It is an international leading high-tech of surveying and mapping, which can realize the synchronous, fast and high-precision acquisition of ground 3D coordinates and image data, and quickly and intelligently realize the real-time, changing and real morphological characteristics of ground objects.

4. Application evaluation of practical model

4.1. Parameter determination of data collection system

Tables 1–3 are the main parameters of UAV platform, transportation and support shelter and ground command and control vehicle.

The above three tables list the specific parameters of the UAV platform in this experiment. Based on the above parameters, the research of the mountain torrent disaster model under multisource data fusion is conducted.

4.2. Evaluation of model application

The excellent level of the platform is evaluated through the statistics of mountain torrent disaster prediction in Southwest China by computer. The mountain torrent disaster in Southwest China is categorized as five regions by geographical location, which are area 1, area 2, area 3, area 4 and area 5. Fig. 6 shows the specific results.

Fig. 6 reveals that the number of mountain flood disasters predicted by computer based on the model is basically in line with the actual number, and the prediction accuracy is more than 80%. The computer prediction of mountain flood disaster in area 4 deviates from the actual number. The reason may be the interference caused by weather conditions on UAV, resulting in the deviation of data collected by UAV. Overall, the mountain torrent disaster model under multisource data fusion is effective.

The actual platform includes a data structure layer, data processing layer, prediction model layer and data service layer. The data structure layer is mainly based on the big data platform, which classifies the multisource data into the serializable data structure based on the actual geographic information to meet the functional requirements of data integration, storage, service, application, security and management; the function of data processing layer is to construct data features that meet the requirements of modeling and to store the data after model prediction output. The data processing layer mainly includes data extraction, data governance, data classification, feature engineering and other parts. The data feature engineering mainly includes data cleaning, data discretization, data coding, data outlier detection and data repair modules. It is the core of this layer, which also greatly affects the final prediction effect of the model; the prediction model is mainly constructed by the combination of traditional analysis and machine learning algorithms. The model primarily includes the mountain flood forecast model, flood disaster early warning forecast model and debris flow disaster monitoring model. Historical data are correlated with measured data. Based on the traditional theory of hydrological system analysis, machine learning, neural network, regression analysis and data operation simulation are adopted to build the data model and optimize the model

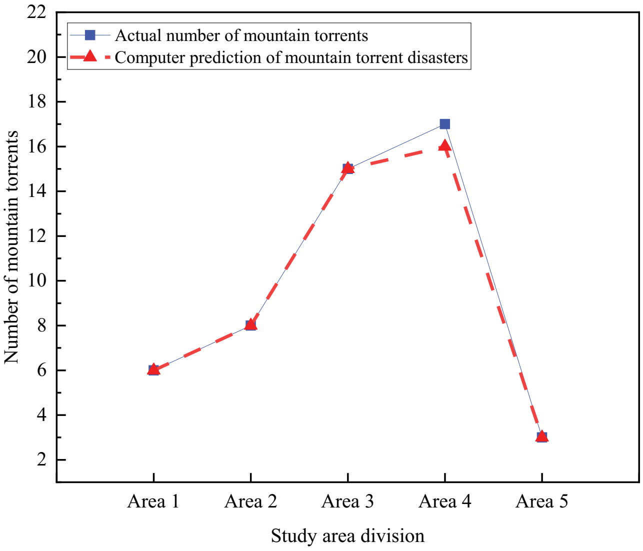

Fig. 6. Comparison between the computer prediction and the actual results of mountain torrent disaster.

Table 1
UAV platform parameters

Wing span, m	4.6
Aircraft length, m	3.4
Body height, m	1.1
Takeoff weight, kg	85
Loading capacity, kg	up to 20
Cruising speed, km/h	120
Applicable ambient temperature, °C	–20–50
Fuel	Gasoline

Table 2
Parameters of transportation and support shelter

Cabin length, m	6.5
Cabin height, m	3
Cabin width, m	2.5
Total transshipment, kg	4,000 (including UAV)

Table 3
Parameters of ground command and control vehicle

Length, m	6.5
Width, m	2.2
Height, m	2.7
Antenna extension height, m	6
Wheelbase	3.8
Approach angle, °	25
Departure angle, °	24
Curb weight, kg	3,750

parameters. The final output data results provide the basis for the decision-makers decision-making and command. These data results and the original data are stored in the data warehouse of the data processing layer, which is convenient for the front and back end to call flexibly; the data service layer is mainly based on the visual intelligent system, with machine learning algorithm and data operation simulation as the theoretical and technical support. Along with the actual situation of regional spatial distribution, multi-directional and multi-angle query, prediction, forecast, early warning chart display are achieved. The historical rules and real-time changes of water level, flood spread, water quantity, material source, disaster risk coefficient and other elements information are visually displayed.

5. Conclusions

This exploration focuses on the perception and fusion of flood and geological disaster data. The purpose is to create a 3D grid of air-ground-water-mud. All kinds of data collected by UAV are analyzed through the data platform and combined with the professional models of flood, debris flow and landslide to perform the correlation analysis. The monitoring point data is expanded into 3D grid data. A light version of mountain torrents, debris flows and landslides big data platform is built through the combination of multisource data fusion components, space-sky-ground 3D grid system, data analysis engine and algorithm model and other key technologies. The platform includes mountain torrent forecasting model and a small visual disaster information system, which can flexibly present monitoring and analysis results. Coupled with two-dimensional and 3D GIS, it can realize real-time and multi-directional hydrological displays. This platform can also connect the disaster data association analysis platform with the manual command and decision-making system, and provide the basis for prediction, decision-making and command. There are some limitations, such as the few sample values selected in the application research. In the follow-up research, multi-sample analysis can be selected to achieve the purpose of higher applicability of the model.

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