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Japanese literature organization and spatiotemporal database system creation for natural disaster analysis

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Abstract

Japan is one of the countries with the most frequent natural disasters in the world and is faced with various threats of natural disasters every year, which significantly impact Japan's social economy and people's lives. A great deal of information about disasters is preserved in Japanese literature. Interpreting and organizing this information help us to analyze the regularity of disasters and understand the preventive measures of ancient people. This paper aims to organize, analyze and save disaster data by collecting various information about disasters. Then a disaster spatiotemporal database system is constructed by using deep learning, image processing, and database technology. The system consists of two parts, namely, the disaster database and disaster website. The disaster database is the core of the whole system, which saves the disaster data after organizing and summarizing. The database collects disaster information from various sources, including key information such as disaster type, time, location, scale, and scope of impact. The Disaster website is the system's user interface, providing an interactive platform for users to access and use disaster data easily. The website has many functions, including search, visual display, disaster information query, etc. We also make a detailed analysis of the collected data, aiming to predict the causes and occurrence rules of disasters so as to achieve the target of disaster prediction.

Keywords Disaster data organization, Character extraction, Character recognition, Disaster analysis, Disaster spatiotemporal database system

Introduction

Japan is an island nation on the Pacific Ring of Fire and the Pacific Earthquake Belt, which is often affected by natural disasters. Over the past decade, Japan has suffered many natural disasters, including powerful earthquakes, typhoons, floods, and heavy rains. Compared to other countries, Japan is prone to natural disasters such as earthquakes, tsunamis, and volcanic eruptions. The land area of Japan is only 0.28% of the whole world. However, 20.5% of the world's earthquakes of magnitude six or higher occurred in Japan, and 7.0% of the world's active volcanoes are in Japan [1]. The most serious is the March 11, 2011 earthquake and tsunami along the Pacific coast of the Tohoku region, which caused more than 15,000 deaths and extensive property damage [2]. In addition, Japan is affected by several typhoons each year, some of which cause disasters such as floods and landslides. Therefore, disaster prediction and analysis have become an urgent issue in Japan. Natural disaster has caused tremendous damage and harm to Japan's social economy, infrastructure, and people's lives. To reduce the loss caused by disasters and protect people's safety, studying disasters becomes particularly important.

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Japanese literature record a wealth of information about natural disasters and the measures taken by the ancient Japanese people to deal with them. In this paper, the category of Japanese literature we have mentioned includes early Japanese books, modern magazines, pictures and hand-drawn drawings. These documents include historical records, history books, local chronicles, official documents, private notes, etc., covering a wide range of periods from ancient times to modern times. These literature records in detail the earthquakes, volcanic eruptions, floods, typhoons, tsunamis and other natural disasters that have occurred in the history of Japan. For example, ancient chronicles such as *Nihonshoki* [3] and *Kojiki* [4] record a large number of natural disaster events, describing earthquakes and volcanic eruptions and their impact on people's lives and society. In addition, some local chronicles and official documents also provide detailed descriptions and relevant data on natural disasters in specific areas.

To predict and analyze natural disasters in Japan, we build a disaster spatiotemporal database system of Japan. The goal of the system is to collect, organize and store a variety of data related to disasters in Japan, including historical disaster records, meteorological data, geographic information, etc. We have collect extensive data on disasters, covering many aspects. When dealing with disaster data, we take two different approaches. For handwritten data preserved in early Japanese books, we use deep learning and image processing technology to identify and extract. For data in the form of prints, pictures, maps, etc., we choose to use Google Docs and manual methods to extract and organize. By integrating these data into a unified database, we are able to better analyze and understand the patterns and trends of disasters. We choose MySQL as the database construction tool, and use HTML, JSP, Echart and other technologies to design and develop database-related web pages. The system not only provides data storage and management functions but also has flexible query and analysis capabilities. Users search and filter disaster data by selecting specific conditions such as time range, place, and disaster type. At the same time, the system also provides a visual display function, the data in the form of maps, charts, etc., to help users more intuitive understanding and analysis of disaster data.

The research work of this paper has made major contributions in two aspects:

- We have conducted a comprehensive collation and induction of disaster data from different sources. Disaster data comes from various sources, including official data, academic studies, and media reports. The data is collated and processed electronically for better preservation and management.
- We build an efficient database system to support the storage, management and retrieval of disaster data. Based on advanced database technology and optimization method, the system has high performance and scalability. It provides a flexible data model and powerful query function, enabling users to access and utilize disaster data easily. At the same time, the system also provides a friendly user interface and data visualization function to help users intuitively understand and analyze disaster data.

The remainder of this paper is arranged as follows. "Related work" introduces the relevant research on disasters. "Problems in the current research" explains the problems in disaster research based on early Japanese books. "Overview of spatiotemporal database system" describes the structure and algorithm of the whole system. "Introduction of disaster spatiotemporal database" introduces the construction of database and data organization. "Introduction of disaster spatiotemporal website" presents the function and layout of the website. "Analysis of disaster results using spatiotemporal database system" analyzes the data collected so far. Finally, the whole system is discussed and summarized in "Discussion and future work" and "Conclusion".

Related work

Disaster database

The researchers have also come up with new ways to collect disaster data [5]. Different data sets for different data types are set up for research [6–8]. Use these data sets for data analysis or import them into a database for efficient preservation and management. The researchers also collected disaster data from plants in nature, using the growth rings of trees to record past climate and environmental changes, thereby revealing past natural disaster events [9].

The research of disasters based on database has made progress. Researchers set up different databases for different data and analyze a large amount of data [10]. In 2019, Bruijn et al. published a paper on a real-time flood database based on social media [11]. The database uses the Twitter platform to monitor flooding in real time around the world and is correct 90% of the time. In 2021, Goulet et al. create a database to record the ground movement of earthquakes [12]. Not only the ground characterization model is established to analyze the ground motion characteristics, but also a large amount of seismic data is collected and time series is established. The application of the database makes disaster research more systematic and comprehensive, and researchers have a deeper understanding of different types of disaster events. By organizing, storing and analyzing disaster data, the database provides a better resource platform for researchers and promotes the development and progress of disaster research.

Character recognition in ancient documents

A lot of ancient information is preserved in the ancient documents, which has attracted the attention of researchers. Researchers use modern techniques to interpret the information preserved in the literature. For example, in Oracle Research, Fujikawa et al. designed a web application to help Oracle[1] re-organization [13]. Yue et al. proposed a data enhancement method based on GAN(Generative Adversarial Network) [14], which overcomes the problem of data set limitation in OBI recognition.

Researchers have used Japan to study the history of natural disasters and human responses to disasters in ancient Japan. These documents, including early Japanese books, local chronicles, official documents, and private notes, recorded disaster events such as earthquakes, volcanic eruptions, and floods, as well as the preventive and anti-disaster measures taken by ancient people [15]. In terms of early Japanese books research, deep learning may become an effective way to organize early Japanese books. Researchers have created a number of neural network models to recognize handwritten characters in early Japanese books [16, 17]. Researchers gain valuable information about ancient disasters by interpreting and analyzing these documents. Although there have been some books on sorting out natural disaster data [18], there are still some deficiencies in data integration and in-depth analysis.

Disaster prediction and analysis

In the field of natural disasters, researchers have been working on the collation and prediction of disaster data. Many studies have explored the regularity and trend of disaster occurrence by collecting and analyzing historical disaster data. Researchers have also been working on earthquake prediction to warn of possible seismic events in advance [19–21], thereby reducing the impact and loss of disasters.

Deep learning techniques have shown great potential in disaster data processing in recent years. Researchers use deep neural networks, convolutional neural networks (CNN), and recurrent neural networks (RNN) to analyze and process disaster images, geographic data, and meteorological data. Researchers have also used CNN models

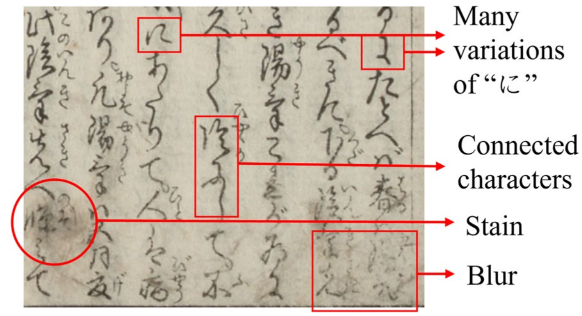


Fig. 1 Problems of early Japanese books image

to predict disasters and have achieved remarkable results [22–24]. In disaster data processing, these models are used to analyze historical disaster data, dig out the regularity and trend of disaster occurrence, and then predict possible disaster events in the future.

Problems in the current research

Problems of early Japanese books organization

Japan has a wealth of undecipherable early Japanese books, which record the rich information in the political, economic, and cultural fields of ancient Japan. For example, they might detail the extent of damage to urban and rural areas from natural disasters such as earthquakes, tsunamis, typhoons, and fires, and how people responded to and recovered from them. By studying these ancient disaster records, we learn valuable lessons and provide references for disaster response and prevention in modern society. However, there are many problems in the interpretation of early Japanese books.

Ancient Japanese writing systems included Kanji and Kana. In the classical writings, however, we also have Kuzushi-ji,[2] a highly decorative form of writing. This writing uses techniques such as deformation, simplification, and serial writing to make already complex characters even more difficult to read. Figure 1 shows the existence of two different ways of writing the same character "に" which is not uncommon in early Japanese books.

Due to the evolution of historical periods and the differences in writing habits, the same character is written in many different ways, which brings certain difficulties to interpretation and understanding. In addition, some ancient writings would be written together to form compound words or phrases, which further increased the difficulty of interpretation, such as Fig. 1. In the case of continuous writing, the boundaries of each word are

[1] A hieroglyphics, which evaluated Chinese characters.

[2] A special kind of written form, referred to as "Kuzushi-ji", meaning "word".

blurred, and it is necessary to understand its meaning and interpret the correct text.

The fragility of ancient writings has caused many classical works to suffer varying degrees of damage during the preservation process, including the loss of parts, damage and mutilation. These problems have brought great difficulties to recovering the original text, requiring scholars to speculate and fill in the gaps. Researchers are focusing on using advanced technology to restore broken characters in early Japanese books. One work of our research team is using artificial intelligence technology to repair broken characters in ancient characters [25]. More specifically, through improved training of the CycleGAN [26] model, it has the ability to understand and predict the original appearance of damaged text in the literature. This has made remarkable progress in repairing broken characters in early Japanese books.

Insect decay is a common problem in the preservation of classical works. Moth decay is caused by pests in books, such as bookworms and moths, which eat the paper, causing the loss of parts or whole pages of text. In addition, the ancient manuscripts may have been affected by other natural factors and man-made damage, such as stains, water damage, tearing, etc., which further damaged the content and form of the classical works. Figure 1 shows problems such as stains and blurring of characters caused by damage in early Japanese books. For these problems, the researchers also proposed some solutions using artificial intelligence. For example, in 2022, Miao et al. carried out in-depth research on noise removal in Chinese ancient documents [27]. Based on the complexity of the structure of ancient Chinese characters, a researcher continuously improves the denoising ability of the model on the basis of the CGAN [28] model, and finally proposes an advanced denoising model based on the Chinese character writing norm model. This model can effectively remove the noise in ancient documents and provide us with useful enlightenment for character extraction and recognition of Japanese ancient documents.

Problems of the disaster data organization

The main reasons for the difficulty of disaster data organization are attributed to two aspects. First of all, the large and varied sources of data are an important reason for the difficulties. Various official data sources are numerous and disorganized. After a disaster occurs, there are many institutions and organizations involved in disaster data collection, such as government departments, local governments, research institutions, and rescue agencies. These agencies use different data collection methods, standards, and formats, resulting in a diversity and confusion of data sources. Collating and summarizing this data requires a lot of work and addressing issues of data consistency and comparability.

Secondly, the various forms of disaster data are another important reason. Disaster data exist in various forms, including digital data, text descriptions, photos, maps, and charts. These different forms of data need to be effectively sorted, organized, and stored for subsequent analysis and use. Processing and integrating these diverse forms of data may require the use of different techniques and tools, such as data mining, image processing, and geographic information systems. Figure 2 illustrates four different forms of disaster information recording, each with its own unique characteristics. First of all, as shown in Fig. 2a, the disaster information recorded in early Japanese books presents the situation that images and characters mixed together. This form of data requires character extraction and recognition to extract text information about disasters from images. Since early Japanese books use Kuzushi-ji, the interpretation and arrangement of characters are more difficult. Secondly, as shown in Fig. 2b, disaster information records in the form of maps are mainly used to record the occurrence location such as floods. Maps provide spatial information to help us understand the geographical distribution and interrelationships of disasters. However, for the disaster information in the map, we need to carry out geographic information integration and spatial analysis in order to better understand and use these data. Figure 2c shows the magazine recording of disaster information, usually using printed text. Information in magazines is quicker and easier to organize than in early Japanese books, because printed text is easier to recognize and understand. This form of data is usually highly readable and accessible, which helps us to obtain and organize disaster information more quickly. Figure 2d shows disaster information recorded in the form of images. For this form of data, we need to subjectively extract the information from the images and organize it into useful data about the disaster.

Overview of spatiotemporal database system

Algorithm 1 Algorithm of spatiotemporal database system

```
Input: disaster type str1; disaster time str2; keyword kw; click on the Japanese map clk
 Output: Japanese map with search result
//STEP1: user select disaster type, disaster time or input keyword in website
//STEP2: receive user requirements, and performs parameter verification
//STEP3: website connects to the database
if connect to database successfully then
    transmit str1, str2 and kw to database;
    generate the corresponding SQL statement according to str1, str2 and kw;
    search corresponding result in database using SQL statement;
    if search result successfully then
        combine the search results and sort data;
    else
        report an error;
    end
    transmit results to website;
    display the results on Japanese map and rank the results on chart;
    Users further select to view specific disaster information by clicking on areas in the map;
    if click the area that users want to check information on the Japanese map clk then
        transmit clk to database;
        generate the corresponding SQL statement according to clk;
        search corresponding result in database using SQL statement;
        if search result successfully then
            transmit results to website;
        else
            report an error;
        end
        output to webpage;
    else
        report an error;
    end
else
    report an error;
end
```

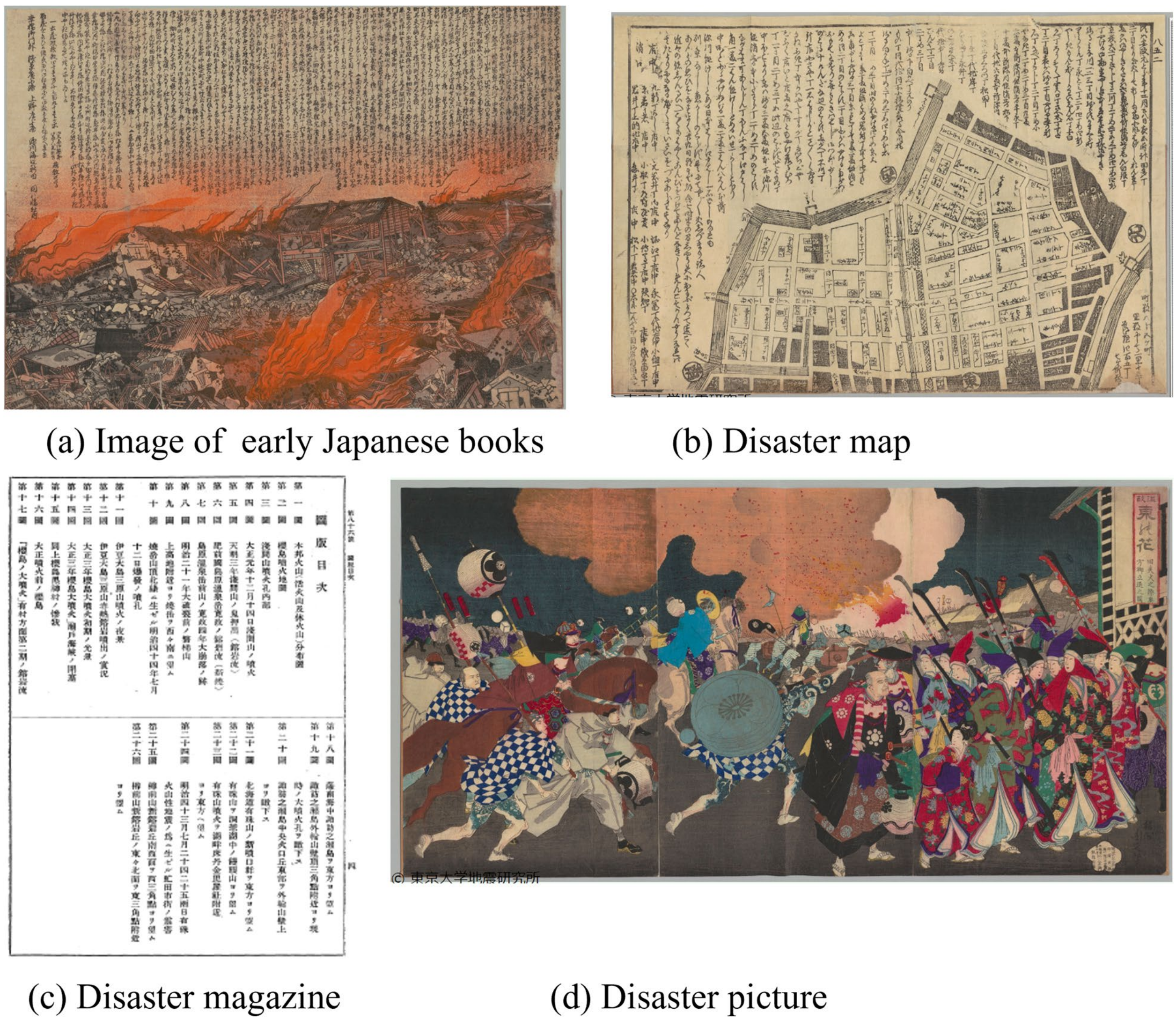


Fig. 2 Various forms of data

In order to realize the prediction of natural disasters in Japan and better understand the spatiotemporal characteristics of disasters, we actively established a disaster spatiotemporal database system for storing and visualizing the location, time, scale, and other important information of natural disasters.

The system we build is mainly composed of a disaster database and disaster website as shown in Fig. 3a, each of which has a specific function and structure.

In the disaster database, we describe in detail the algorithms used to build the database and how the data is organized. We introduce the data sources, which provide us with a wealth of disaster data, including detailed information such as the time, location and scale of disasters. Then, we introduce the data organizing methods, including the character recognition of early Japanese books, the analysis and processing of picture data, the conversion of printed data and so on. Through these organization methods, we are able to extract important information about disasters from different types of data and store it in a database.

In the disaster website, we describe in detail the functions and layout of the website. First, we introduced the features of the website, including the search function and the display function. The search function allows users to search disaster data by disaster type, time range and location, while the display function presents the search results to users in the form of maps and lists. In addition, we also introduce the layout of the website, dividing the website into search areas, map areas, ranking areas,

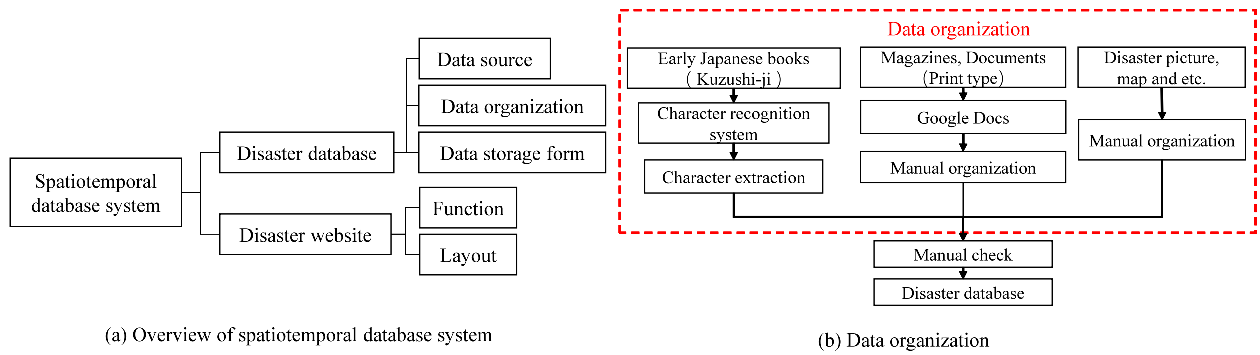


Fig. 3 Overview of spatiotemporal database system and data organization

detailed information areas and distribution of all disasters, so that users browse and obtain disaster data more easily.

Through the combination of the database part and the website part, we build a fully functional and easy-to-use system, which provides users with convenient and fast disaster data query and display services. The data collation and storage of the database part ensure the accuracy and integrity of the data, while the function and layout of the website part provide a good user experience and operability. Such a system architecture helps us better understand and use disaster data, and provides support and guidance for disaster research and management.

For ease of understanding, the complete algorithm for our database is presented in Algorithm 1. The specific steps of the algorithm are as follows:

Step 1: Users make search requests, including the choice of disaster type, time frame, and location.

Step 2: The system receives user requirements, and carries out parameter verification and processing to ensure that the input data format is correct and meets the requirements of the system.

Step 3: According to the disaster type, time range, and place selected by the user, the system carries out the corresponding query operation in the database to obtain the disaster data matching the user's needs.

Step 4: The system takes the data and sorts it according to the number of disasters that have occurred.

Step 5: The system displays the sorted result to the user. On the map of Japan, the number of disasters in each region is marked by the depth of color, and the results are provided in the form of a list for users to refer to.

Step 6: Users further choose to view specific disaster information according to the displayed results. By clicking on an area on the map, users get detailed disaster information for that area.

Step 7: The system extracts the detailed information of the selected area or option from the database, including disaster name, scope, type, time, etc., and displays the information to the user. Users continue the search operation or return to the previous step to modify the search criteria as required.

Introduction of disaster spatiotemporal database

The source of disaster data

The collation of disaster data in ancient Japanese classics is obtained from multiple sources, including the following two main sources:

The first source is the homepage of Japan's Cabinet Office Disaster Management [29]. This website publishes information on disasters and records the details of the occurrence of disasters. This information includes the time, location, size, scope of impact, and the death toll of the disaster. The homepage of Japan's Cabinet Office Disaster Management is an authoritative data source provided by government agencies, providing disaster statistics and relevant information, which is used as an important reference for sorting out disaster data in early Japanese books.

Another source is the Earthquake Research Institute Library, the University of Tokyo [30]. As an important institution for earthquake research, the Earthquake Research Institute Library maintains a large amount of disaster-related data. The data includes records and research on natural disasters such as earthquakes, floods, and typhoons. The Earthquake Research Institute Library's data include ancient documents, photos, newspapers, magazines, animations, and other forms. Through the collection of the Earthquake Research Institute Library, important information about ancient disasters is obtained.

As shown in Fig. 3b, we found three main types of data in the process of data collection: early Japanese books data, printed data, and picture data. These different types of data require specific processing methods. For early Japanese books, we proposed a system of automatic character recognition, and extract the recognized characters. This system has undergone several stages of processing, and at present, we have been able to correctly identify 70% text on a page of early Japanese books image. For the use of printed data, such as magazines, documents, etc., we use Google Docs [31] to transform these data into editable text states. For some data that cannot be recognized by machines, such as pictures and maps, we need to carry out manual sorting and interpretation. With human effort and expertise, we subjectively extract the information in the pictures and collate it into usable data. This manual collation process ensures the accuracy and completeness of the data. In the following, the organizing methods of these three types of data are introduced in detail.

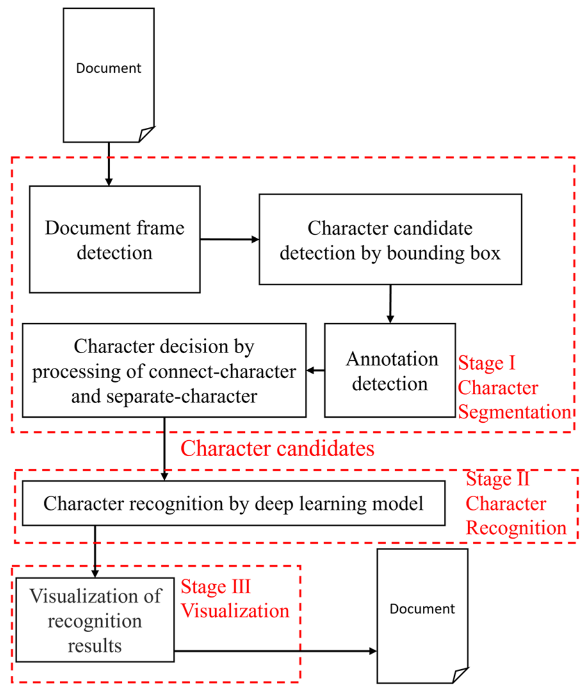


Fig. 4 Character recognition system

Methods of organizing data

Kuzushi-ji organization

Aiming at the disaster data stored in early Japanese books, we propose an automatic character recognition system for the recognition and collation of early Japanese books [32]. The system consists of three stages, as shown in Fig. 4, which are character segmentation, character recognition, and visualization. The three stages are explained in detail below:

Character segmentation: At this stage, the system extracts character areas from images of early Japanese books. This step utilizes computer vision techniques, such as edge detection, character detection, and segmentation algorithms, to locate and extract characters from the image. Through this process, the system accurately extracts the character areas in the image, so as to prepare for the subsequent character recognition.

Character recognition: At this stage, the system identifies the extracted character area. Character recognition technology uses machine learning and deep learning methods to train models to recognize characters in early Japanese books. The models are trained to identify different ancient Japanese characters and turn them into editable and searchable text. The development speed of artificial intelligence is very rapid, and the application of deep learning models in various fields has achieved remarkable results. For example, AlexNet [33], one of the milestones in the field of deep learning, is well used in the field of speech recognition and natural language processing. As more advanced deep learning models are proposed, deep learning models show better performance and effects in different fields. Models such as ResNet [34], Inceptionv2 [35], MobileNet [36] and others have made remarkable progress in image recognition, object detection, natural language processing and other tasks. In this system, we use four deep learning models for experiments, namely GoogleNet [37], VGG [38], InceptionV3 [39], MobileNetV2, aiming to select the most suitable model for character recognition. By comparing the experimental results, we finally chose MobileNetV2 with the best effect as the character recognition model. MobileNetV2 is a lightweight convolutional neural network model with low computational complexity and parameters while maintaining high accuracy. This makes it well suited for the task of word recognition, especially for texts in early Japanese books, where there are many ways of writing and complex ways of writing. By using the MobileNetV2 model, we accurately identify most of the text content in the images of early Japanese books, which provides a reliable basis for further data collation and analysis. This model selection method improves the accuracy and efficiency of the system and provides a feasible solution for the processing and utilization of disaster data in early Japanese books.

Visualization: In this stage, the system recognizes the character results for sorting and representation. The identified characters proofread and corrected to improve the accuracy of recognition. The system converts the recognized character into a standard text format, such as Unicode encoding, for easy storage, retrieval and analysis. Through this process, the resulting textual data are easily used by researchers, scholars, and other users for further analysis, research and utilization.

At present, the system correctly identifies 70% of the character in a page of early Japanese books. This indicates that the system has achieved a certain recognition accuracy, but there is still room for improvement. With the continuous development of technology and optimization of algorithms, the recognition rate of the system is expected to be further improved, so as to more effectively process and collate disaster data in early Japanese books. Figure 5a shows the result of character recognition of early Japanese books by an automatic character recognition system. The recognized results are displayed on the original image and are exported as editable text. In this way, we extract disaster-related information from these identified texts and conduct further organization and analysis.

Print type data organization

We encountered some printed data, such as magazines, documents, etc., which are usually not convenient for direct machine recognition and data organization. To overcome this problem, we used the Google Docs tool introduced by Google to transform this data into a state of editable text.

Google Docs is a powerful online document editing tool that recognizes and converts printed text into editable electronic text. By using Google Docs, we scan or input the text content of printed data such as magazines and documents into the tool, and then through its built-in Optical Character Recognition (OCR) technology, convert the text in an image to a computer-readable text format. By using Google Docs to transform and organize printed data, we are able to quickly obtain editable versions of these data for subsequent data analysis, database import, and disaster research. This step provides us with a more comprehensive and diverse data source for our research and helps us better understand the disaster information recorded in ancient literature, so as to advance relevant research on disaster prevention and prediction.

As shown Fig. 5b, we use Google Docs to export the printed text in the magazine to an editable text state. This process is achieved through optical character recognition technology, which converts the text on magazine pages into a computer-readable text format.

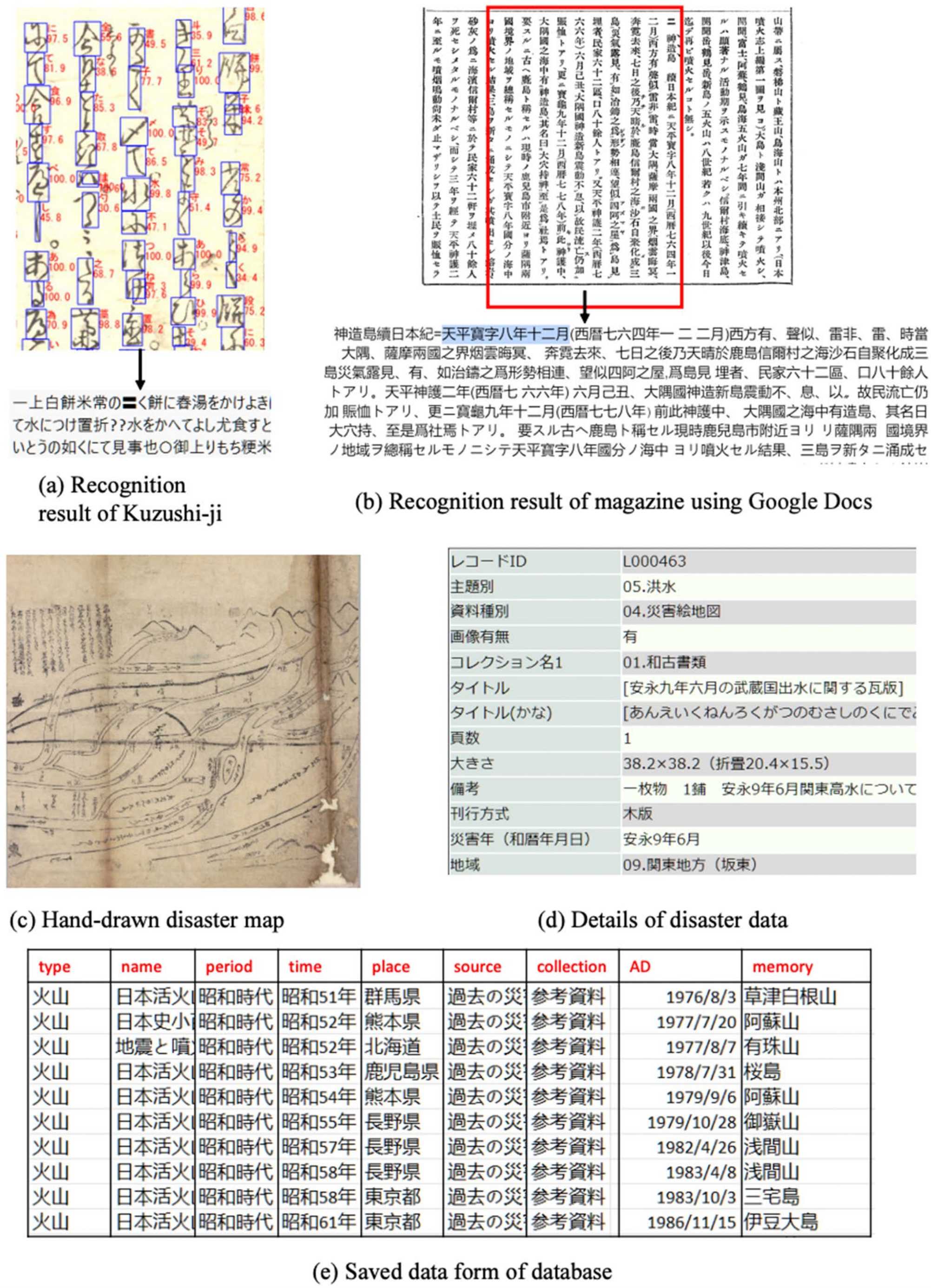
Pictures organization

For some disaster data that cannot be automatically sorted through character recognition, such as disaster maps, photos, and other non-textual data, it is necessary to rely on manual sorting and processing. These non-textual data contain geospatial information, visual information, and other perceptual data about the occurrence of disasters, which are crucial to the understanding and analysis of disasters. First of all, it is necessary to collect disaster maps, photos, and other relevant data in Japanese literature. These data may be scattered in different Japanese literature and need to be collected through research and data collection. In the process of collection, it is also necessary to select disaster-related data with research value. Relevant non-textual data is collected, digitized, and converted into a digital format for easy storage and management. These non-textual data are sorted and classified by classifying and labeling the data according to the type of disaster, time, location, and other key information.

These data cover a variety of disasters, including but not limited to floods, fires, and earthquakes, and span the entire history of Japan. We illustrate our arrangement and presentation of these data with a flood image from the Edo period. Figure 5c shows the map of the flood areas that occurred in Japan during the Edo period. For this kind of map data, we need to organize and extract the data recorded when saving. Figure 5d shows the key information on the map. We record and organize the key information on the map. After sorting and extraction, we choose to use the Excel table for recording. In the table, we see the details of each flood event, including important information such as when and where it happened, the size of the flood, and the extent of its impact. The collation and recording of these data provide preparation for subsequent database import and analysis.

Data storage form

We use MySQL as the database building platform. MySQL provides us with an efficient and secure data storage and retrieval mechanism. In terms of database management, we use SQL statements to perform various operations to ensure efficient processing and flexible management of data. We currently store more than 2000 pieces of data in our database, as shown in Fig. 5e and each piece of data contains key elements, including the specific date and time of the disaster event, the location or geographic location of the disaster, and the specific type or category of disaster. In addition, additional information is recorded, such as the extent of the damage caused by the disaster, the number of people affected, and the post-disaster reconstruction efforts. The accuracy and clarity of the information provide us with a solid



レコードID	L000463
主題別	05.洪水
資料種別	04.災害絵地図
画像有無	有
コレクション名1	01.和古書類
タイトル	[安永九年六月の武蔵国出水に関する瓦版]
タイトル(かな)	[あんえいくねんろくがつのむさしのくにで
頁数	1
大きさ	38.2×38.2（折畳20.4×15.5）
備考	一枚物　1舗　安永9年6月関東高水について
刊行方式	木版
災害年（和暦年月日）	安永9年6月
地域	09.関東地方（坂東）

(d) Details of disaster data

type	name	period	time	place	source	collection	AD	memory
火山	日本活火	昭和時代	昭和51年	群馬県	過去の災	参考資料	1976/8/3	草津白根山
火山	日本史小	昭和時代	昭和52年	熊本県	過去の災	参考資料	1977/7/20	阿蘇山
火山	地震と噴	昭和時代	昭和52年	北海道	過去の災	参考資料	1977/8/7	有珠山
火山	日本活火	昭和時代	昭和53年	鹿児島県	過去の災	参考資料	1978/7/31	桜島
火山	日本活火	昭和時代	昭和54年	熊本県	過去の災	参考資料	1979/9/6	阿蘇山
火山	日本活火	昭和時代	昭和55年	長野県	過去の災	参考資料	1979/10/28	御嶽山
火山	日本活火	昭和時代	昭和57年	長野県	過去の災	参考資料	1982/4/26	浅間山
火山	日本活火	昭和時代	昭和58年	長野県	過去の災	参考資料	1983/4/8	浅間山
火山	日本活火	昭和時代	昭和58年	東京都	過去の災	参考資料	1983/10/3	三宅島
火山	日本活火	昭和時代	昭和61年	東京都	過去の災	参考資料	1986/11/15	伊豆大島

(e) Saved data form of database

Fig. 5 Methods of organizing data

foundation for in-depth study and analysis of ancient disasters. Through the collation and induction of a large number of data, we found the spatial and temporal distribution of disasters, the impact characteristics of different types of disasters, the effectiveness of post-disaster response measures and other aspects of information.

Introduction of disaster spatiotemporal website

The disaster spatiotemporal website is used to display our research results and disaster data. In terms of web design, we use HTML, JSP, Echart and other front-end technologies. We use HTML to build the basic framework and elements of web Pages, and interact with the database in the background through JSP (JavaServer Pages) to achieve the generation and display of dynamic web pages. Echart presents the information from our database on the web in the form of intuitive, clear graphs. Our website provides a user-friendly interface and interactive features that make it easy to browse and query data in the database. The disaster data are displayed in an intuitive and easy-to-understand way through maps, charts and other visualization methods, so as to have a deeper understanding of the occurrence, trend, and impact scope of disasters.

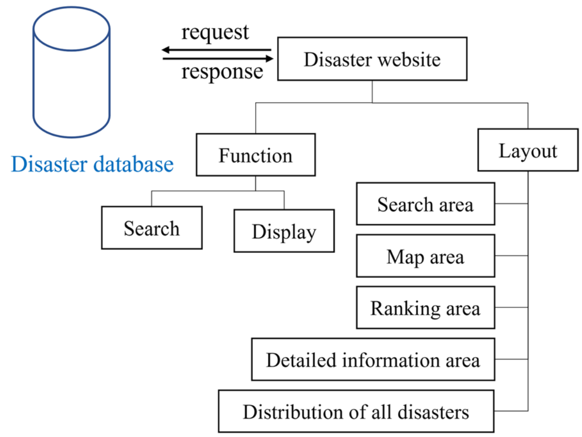


Fig. 6 Functions and layout of disaster website

Functions of disaster spatiotemporal database system

As shown in Fig. 6, the database system has two main functions: the search function and the display function. The search function allows users to search for disaster data in the database based on specific criteria. Users select disaster type, time range, location, etc. as search criteria to obtain data results relevant to their needs. The display function is used to display the disaster data in the database on the map. Through the map display, users intuitively understand the occurrence of disasters in various regions.

Search function

The search function of the disaster database system is very important, through the search quickly locate and obtain the required disaster information. To provide a more flexible and convenient search experience, we have implemented two main search methods in the disaster database system.

First, we provide a filter-based search. Users find disasters that occurred somewhere in Japan's history by selecting a specific type of disaster, time frame, and location, as shown in Fig. 7. By selecting disaster categories, such as earthquakes, floods, and typhoons, users focus their search on specific types of disasters. Users also set a period range to limit search results to a specific period of time. The selection of location is carried out by selecting the region and city in order to more accurately locate the required disaster information. This search method is used to obtain disaster data related to its research or concern based on specific conditions.

Secondly, we also provide the keyword search function, which directly enters the keywords related to disaster to search the relevant disaster information. Figure 8 shows the result after typing the keyword "善光寺", which is located in Nagano Prefecture. Users enter different keywords according to their interests and requirements, such as specific locations, disaster names, impact factors, etc. The system matches the keywords in the database and returns disaster data related to the keywords. This search method is not only suitable for specific disaster events but also helps users discover potential associations and commonalities.

The combination of these two search methods enables users to obtain the required disaster information more comprehensively. Whether users want to delve deeper into a specific type of disaster or learn about the history of disasters in an area, users quickly access relevant data by selecting filters or entering keywords directly. This flexible and diverse search capability enhances the usability and usefulness of the database, making it easier for users to utilize the disaster database system for research, decision making and risk management.

Display function

In order to visually display the spatial distribution of the disaster data, we use the map of Japan in the display area of the disaster spatiotemporal website and use the color intensity to represent the number of disasters in each region.

When the user does a disaster search and gets relevant results, these results are dynamically displayed at the corresponding location on the Japan map. The number of disasters occurring in each Japanese region is shown by the shade of the color. Generally speaking, the stronger the color, the greater the number of disasters in the area, and the lighter the color.

This color-based visualization enables users to understand the spatial distribution characteristics of disasters at a glance. Users quickly identify areas with frequent disasters and those with relatively few

Fig. 7 Search area

disasters by looking at color changes on the map. Such visualizations not only make it easier for users to visually compare and analyze disaster data but also help them identify potential geographic patterns or trends.

In addition to the color representation on the map, we also provide the corresponding legend or ruler so that users accurately understand the relationship between the color and the number of disasters. Users refer to legends to interpret the meanings of colors and compare disaster situations between different regions. This visualization method is not only easy to understand, but also effectively conveys the spatial distribution characteristics of disaster data and helps users better understand and use the data.

These two functions work together to make it easy for users to search and browse disaster data in the database. The search function provides customized search options to help users quickly obtain data under specific conditions, while the display function provides intuitive visualizations in the form of maps, allowing users to more intuitively understand the distribution and trend of disaster occurrence. The combination of these functions provides users with a comprehensive and easy-to-use database platform that facilitates the exploration and analysis of disaster data.

Layout of disaster spatiotemporal website

The region division of the website mainly includes five parts: search area, map area, ranking area, detailed information area and distribution of all disasters. The search area is dedicated to finding and searching data. The map area is mainly used to display the spatial distribution of disaster data on the Japan map. The ranking area is used to display the ranking of disaster data. The detailed information area is used to display the details of the selected disaster data. Distribution of all disasters shows different disasters in the same area in different periods.

Search area

In the search area of our disaster spatiotemporal website, users select the region, disaster type, and time to filter the data, so as to obtain disaster information under specific conditions. First of all, region selection is an important screening condition. We provide coverage for all regions of Japan, including Hokkaido, Tohoku, Kanto, Tyubu, Kansai, Tyukoku, Shikoku, and Kyushu, as shown in Fig. 7. Users search according to their needs. Such a range of options allows users to gain insight into the disaster situation in a specific area or compare disaster differences between different areas. Secondly, disaster type is another important screening condition. We provide a variety of disasters for users to choose from, including earthquakes, volcanoes, tsunamis, fires, floods, storms,

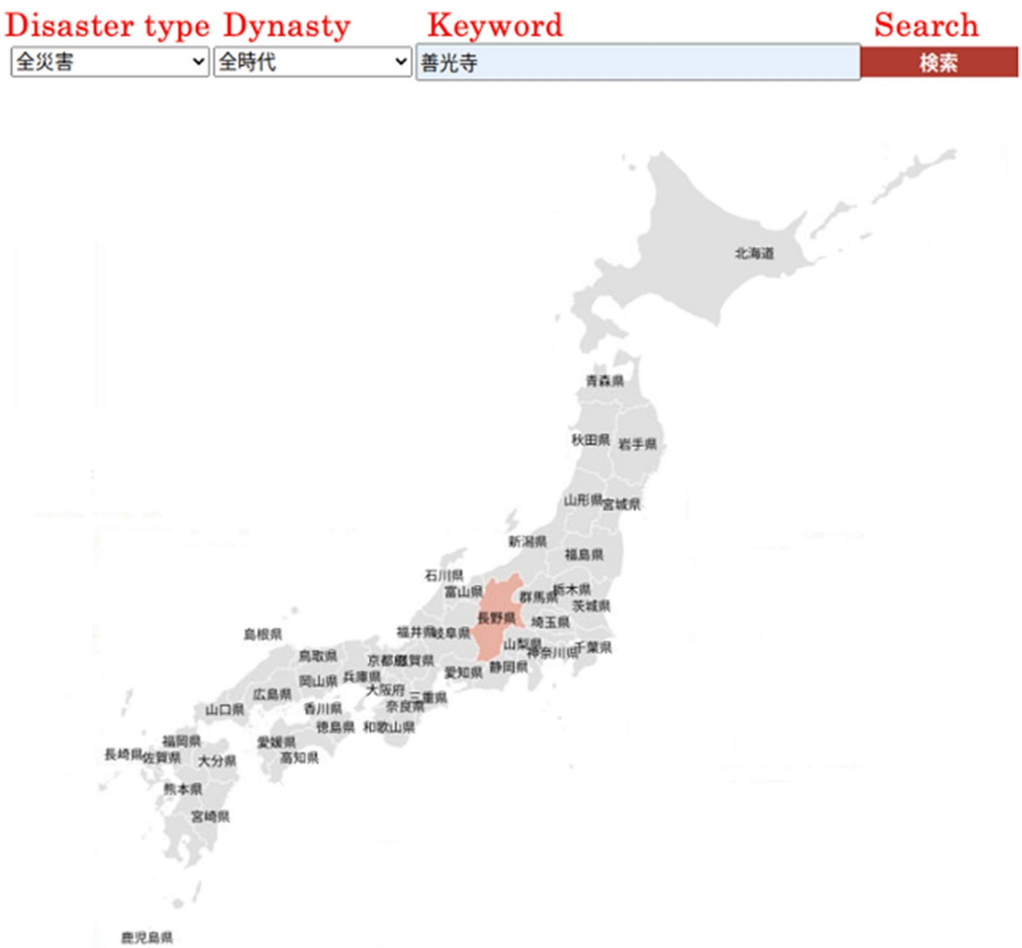


Fig. 8 Search using keyword

and so on. Users select one or more disaster categories to search based on their research or interests. Such disaster categorizations enable users to focus on specific types of disasters to gain a deeper understanding of their characteristics and impacts. Finally, time selection is used to limit the time range of search results. Our database covers disaster data from the Paleolithic period in Japan all the way to the Reiwa period (AD.645 to 2021). Users search in a range of time periods based on their research or specific historical periods of interest. Such time selection help users more precisely locate the required disaster data to meet their specific research or analysis needs. By selecting the region, disaster type, and time range, users customize the disaster data according to their own needs. This filtering function enables users to obtain the data of interest more precisely, thus improving the efficiency and accuracy of the research. At the same time, it also provides users with more flexible opportunities to explore and compare disaster situations under different conditions, contributing to an in-depth understanding of Japan's natural disaster history and trends.

Map area

Our disaster spatiotemporal website provides an intuitive way to present the data by showing the number of disasters occurring in different regions on a map of Japan. To make it easier for users to differentiate the frequency of disasters in different regions, we use different colors. Depending on the number of disasters in each area, we use a gradient representation on the map. In general, areas with a higher frequency of disasters are marked with darker or saturated colors, while areas with a lower frequency of disasters are marked with lighter or lighter colors. Such a gradient scheme helps users visually compare disaster situations across regions and quickly identify areas with high or low frequency of disasters. For example, if an area has a high number of disasters, we might choose to use a dark red color to mark the area. For areas with fewer disasters, we might choose to use

Fig. 9 Jpanese map with disaster information

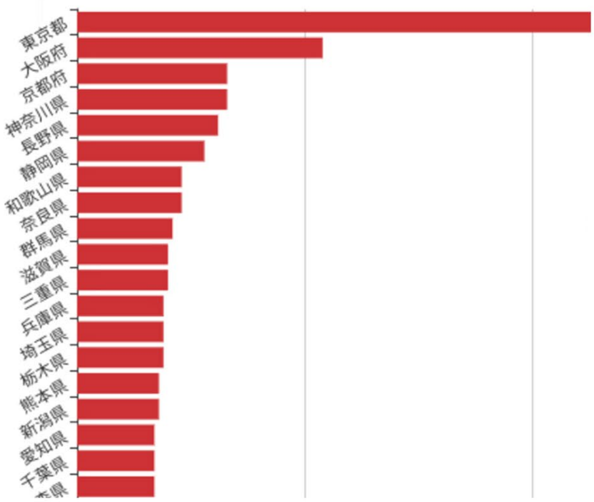
light red. In Fig. 9, this is a map of earthquake distribution over time. This color-based variance scheme allows users to see the disaster frequency differences across regions at a glance, allowing for better comparison and analysis.

Ranking area

On our disaster spatiotemporal website, we provide a list of rankings showing the number of disasters occurring by region. The ranking list is arranged in descending order of the number of disasters occurring, placing the most frequent areas first and the less frequent areas lower as shown in Fig. 10a. This arrangement allows users to see at a glance the differences in the intensity of disaster activity across regions. In the ranking list, the name of each region and the corresponding number of disasters are displayed. Users get an overall impression by looking at the top of the ranking list, or by looking at the bars in the chart. Users intuitively understand which regions have experienced more disasters, so as to have a more in-depth study of disaster characteristics and disaster prevention measures in these regions. This helps users quickly identify areas with a high frequency of disasters and provide important references for decision-making, risk assessment, and resource allocation.

Detailed information area

On our disaster spatiotemporal website, we offer the ability to interact with a Japan map, allowing users to click on any area of the map to obtain detailed information about natural disasters in that area as shown in Fig. 10b. This interactive feature helps users gain insight into disaster events in a specific region and provides more specific data and content. When a user clicks on a specific area on the map, the website responds immediately and brings up an information box or pop-up with details of natural disasters related to that area. These details include important data such as the name, extent, type, and time of occurrence of the disaster. Through this interactive function, users select a specific region for query according to their interests and needs and obtain the natural disaster information related to the region. This provides users with more specific and targeted data to help them get a complete picture of the disaster situation in various regions of Japan.

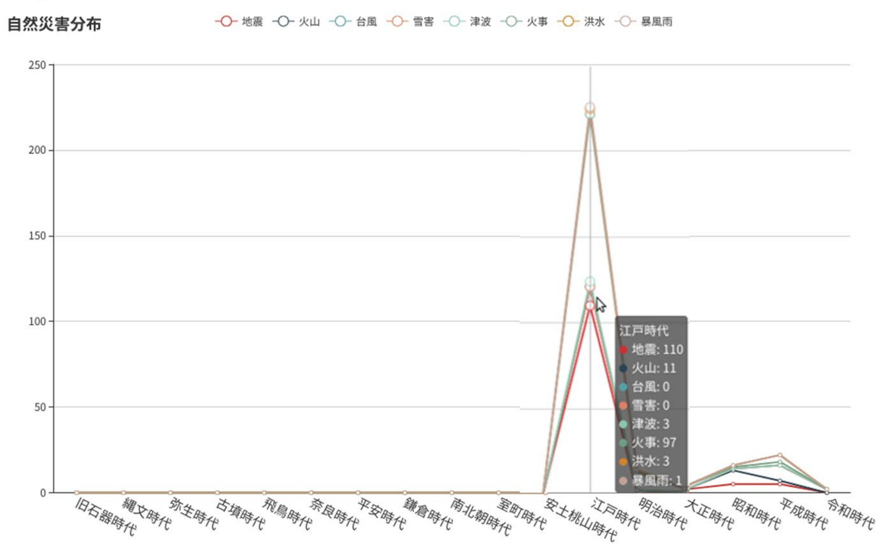


(a) Ranking of disaster numbers

詳しい情報

災害地方	災害種類	災害時代	災害時間	災害名前
中部地方	地震	江戸時代	安政1年11月	諸國大地震大津波実説早引方角附　世直り一覧　嘉永七年甲寅十一月四日・五日
中部地方	地震	江戸時代	安政1年11月	諸國大地震并大津浪
中部地方	地震	安土桃山時代	天正13年	理科年表
中部地方	地震	江戸時代	宝永4年	理科年表
中部地方	津波	江戸時代	安政1年11月	諸國大地震大津波実説早引方角附　世直り一覧　嘉永七年甲寅十一月四日・五日
中部地方	津波	江戸時代	安政元年11月	諸國大地震并大津浪
全国	地震	江戸時代	安政2年10月	ぢしんの辨
全国	津波	江戸時代	安政2年10月	ぢしんの辨
長野県	火山	江戸時代	天明3年7月	信州淺間山大焼上州郡馬郡吾妻郡流失村々記之
長野県	火山	江戸時代	天明3年	浅間山焼出記
長野県	火山	江戸時代	天明三年	天明三年淺間大焼之圖
長野県	火事	江戸時代	嘉永7年11月4日	安政東南海地震に関する絵図
長野県	火事	江戸時代	弘化4年3月24日	善光寺地震に関する瓦版
長野県	火事	江戸時代	弘化4年3月24日	弘化丁未信濃國大地震山川崩激之圖
長野県	火事	江戸時代	弘化4年3月24日	弘化丁未信濃國大地震山川崩激之圖　共二
長野県	火事	江戸時代	安政1年11月4日	諸國大地震
長野県	洪水	江戸時代	弘化4年	善光寺地震に関する瓦版
長野県	洪水	江戸時代	弘化4年3月	弘化四年信濃地震洪水圖
長野県	洪水	江戸時代	弘化4年3月	弘化丁未信濃國大地震山川崩激之圖
長野県	洪水	江戸時代	弘化4年3月	弘化丁未信濃國大地震山川崩激之圖　共二

(b) Detailed information



(c) Distribution of all disasters in Tokyo

Fig. 10 Ranking area, detailed information area and distribution of disasters

Distribution of all disasters

In order to facilitate the observation of the distribution of natural disasters in specific regions in different time periods, we use the form of line charts to display the data. This intuitively displays the changing trend of time series data, so that users more easily understand and analyze the occurrence and evolution of disaster events. In a line chart, the horizontal axis represents time and the vertical axis shows the number of disaster events. Each line represents one type of disaster data for that particular region, and the data is differentiated by different colors. As shown in the Fig. 10c, we show the distribution of natural disasters in Tokyo in different times. The figure shows that the disaster distribution of the Edo period is more, mainly because the disaster data of the Edo period is collected and sorted out in the process of data collection.

In addition, in order to facilitate users to observe the relationship between different disasters, we design a function that hides or shows broken lines. This feature allows users to selectively display certain types of disaster data and hide other disaster data to more centrally compare and analyze the disaster events of interest.

Analysis of disaster results using spatiotemporal database system

In order to verify the validity of the database, we perform a disaster analysis using the data held in the current database. By digging deeper into the correlation between disasters, we show the current function of the database on the one hand, and better understand the patterns and trends of disasters in history through disaster analysis on the other hand. This process not only helps verify the usefulness of the database, but also lays the foundation for our future work. Through the cross-analysis of multiple dimensions such as time, place and disaster type, we can reveal the potential correlation between different disaster events. Through the collation and statistics of the data, we gain some key insights and trends that help us better understand the characteristics and effects of disasters. In this section, we provide a detailed analysis of the locations of tsunamis and volcanoes in Japan, explore their causes, and suggest measures to be taken based on these causes. At the same time, we also delve into the relationship between two of the most common disasters, earthquakes and tsunamis, and deepen our understanding of these natural disasters by exploring and demonstrating the connection between the two disasters.

Analysis of the tsunami in Japan

As can be seen from Fig. 11a, the area where the tsunami occurred in Japan is concentrated on the eastern coast, especially in Aomori Prefecture and Shizuoka Prefecture. Surprisingly, the place with the highest number of tsunamis is Hokkaido, as shown in the Fig. 11b. This finding catches our attention, and we conduct some analysis to understand the reasons behind this phenomenon.

Hokkaido is Japan's northernmost island, located on the edge of the Pacific Ocean, near the source of tsunami waves. This means that Hokkaido is more vulnerable to tsunamis triggered by events such as undersea earthquakes, undersea landslides caused by earthquakes, or volcanic eruptions.

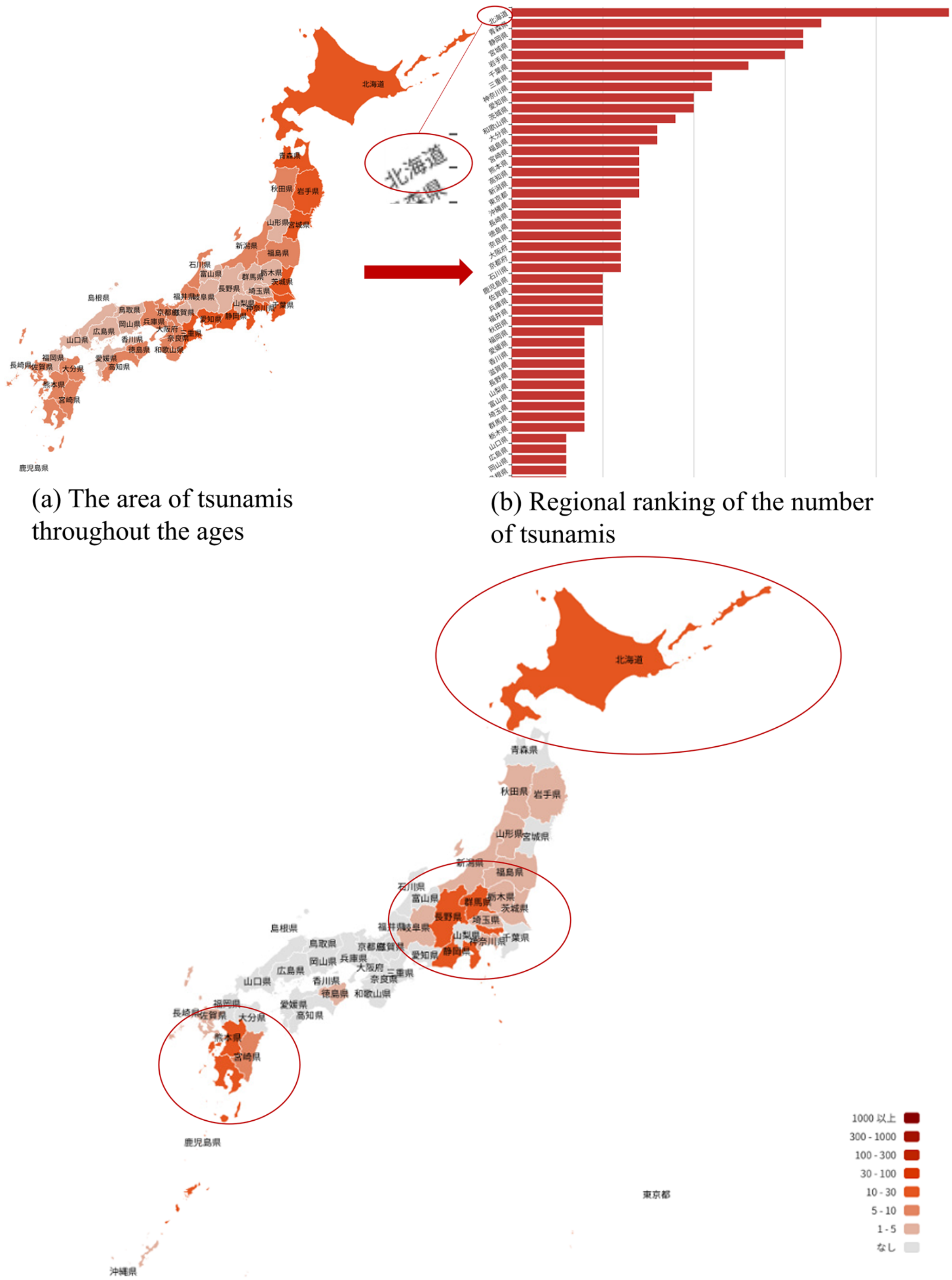
In view of the above situation, a series of preventive measures can be taken to prevent tsunamis. Tsunamis are mostly triggered by undersea earthquakes, so when building houses offshore, it is necessary to consider the seismic rating and lightweight building structure to improve the earthquake resistance of the house. Especially in Hokkaido, such a low-temperature area, it is necessary to choose construction materials and structures to ensure the warmth of the house, as well as safety in the event of earthquakes and tsunamis.

Analysis of volcanic eruptions in Japan

As can be seen from the Fig. 11c, Japan's northern volcanoes are concentrated in Hokkaido, the central volcanoes are concentrated in Nagano, Shizuoka and Gunma prefectures, and the southern volcanoes are concentrated in Kumamoto and Kagoshima prefectures. This volcanic distribution is attributed to a combination of factors.

Japan lies on the Pacific Ring of Fire, where several tectonic plates meet. The northern volcanoes are concentrated in Hokkaido, in part because Hokkaido lies at the junction of the Pacific and Eurasian plates, where plate movement triggers volcanic activity. The central volcanoes, concentrated in Nagano, Shizuoka and Gunma prefectures, are located at the junction of the Philippine Sea Plate and the Pacific Plate, where tectonic movement between plates causes the volcanoes to form. The southern volcanoes are concentrated in Kumamoto and Kagoshima prefectures, located at the junction of the Philippine Sea Plate and the Eurasian Plate, which is also a relatively active area of volcanic activity.

Based on the above problems in volcanic eruptions, we propose some measures. First of all, volcanic areas are often accompanied by seismic activity, so special structures and materials should be used in the construction of houses to increase earthquake resistance. Secondly, the building near the volcano should take fire prevention measures, such as the use of flame retardant materials in the house, the setting of fire alarm systems and fire extinguishing equipment. Finally, the government should



(a) The area of tsunamis throughout the ages

(b) Regional ranking of the number of tsunamis

(c) Volcanic eruption area in Japan

Fig. 11 Tsunami occurred area in Japan

properly plan shelters for residents to take refuge in the event of a volcanic eruption.

Analysis of the relationship between earthquake and tsunami

We compare and contrast the earthquakes and tsunamis that occurred in four coastal regions (Yamagata Prefecture,

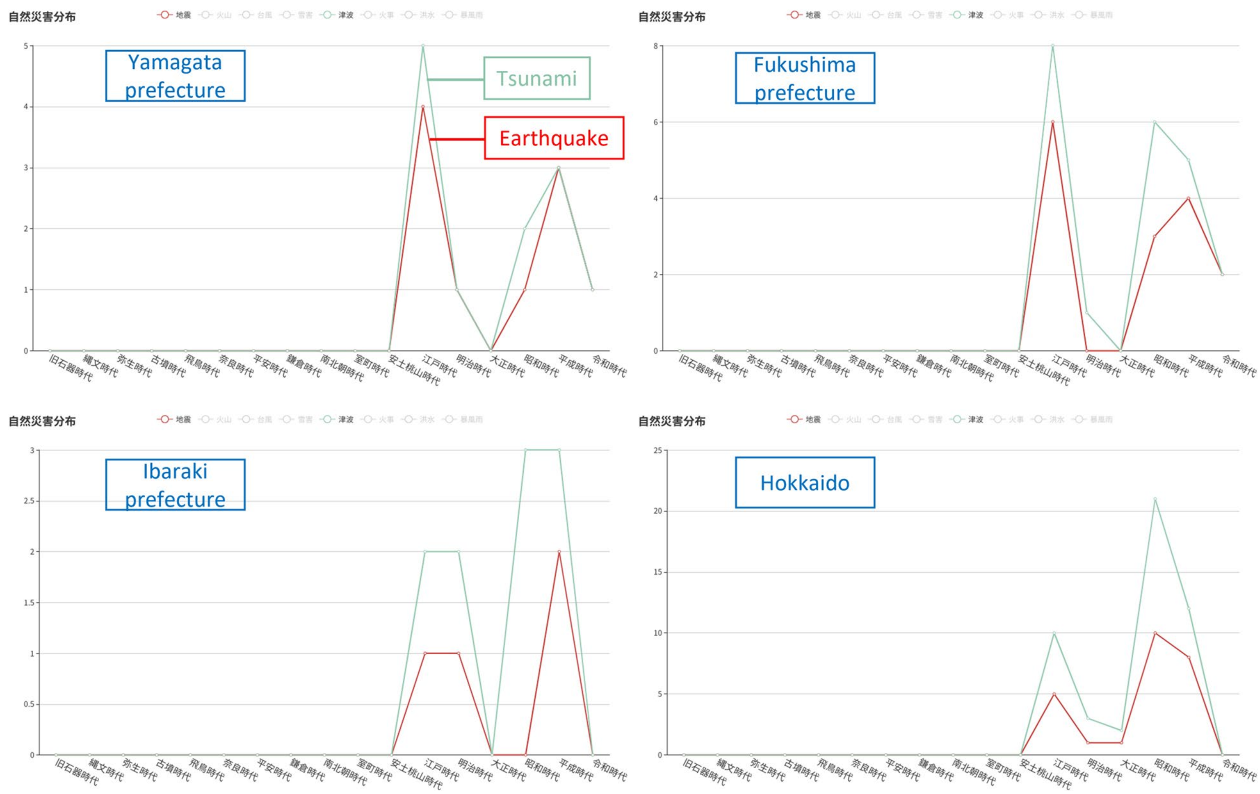


Fig. 12 The relationship between earthquake and tsunami in four prefectures

Fukushima Prefecture, Ibaraki Prefecture and Hokkaido). Through the display of the graph, we intuitively observe the trend of earthquakes and tsunamis in these regions, and try to understand the correlation between them.

As shown in Fig. 12, the trend of earthquakes and tsunamis in these four coastal areas is almost consistent, with similar ups and downs and peaks in time. These results suggest that there is indeed a high potential for tsunamis when earthquakes occur in these coastal areas. This correlation is a phenomenon worthy of attention in geology and geography.

In response to these findings, the government should attach great importance to and strengthen earthquake and tsunami warnings in coastal areas. The establishment of an effective early warning system gives timely warnings to residents so that they have enough time to take measures to reduce the loss of disasters. In addition, in urban planning and construction, more attention needs to be paid to earthquake and tsunami risk assessment and preventive measures in coastal areas to ensure earthquake resistance and protection of buildings and infrastructure.

Discussion and future work

We have successfully built a Japanese spatiotemporal database system, and its various functions are described in detail in the introduction. However, we are also aware that there are some problems with the current database, mainly including insufficient data volume and relatively few features.

First of all, the amount of data in the database is not enough is a problem. Despite our efforts to collect a large amount of disaster data, there are still some missing and incomplete pieces. To improve the integrity and accuracy of the database, we plan to further expand the scope of data collection and collaborate with more data sources, including government agencies, research institutions, and civil society organizations, to obtain more comprehensive and detailed disaster data. In the future, we aim to expand not only the volume of data in our disaster database, but also the diversity of data through in-depth cooperation with these institutions. This contributes to a more comprehensive understanding and analysis of various disaster events, thus providing a more reliable basis for research and forecasting. Secondly, the relatively small functionality of the database is also an area that needs improvement. At present, the database mainly provides search, display and basic analysis functions, but the function of disaster prevention has not been fully utilized. In order to better deal with disaster risks and provide practical preventive measures, we plan to further develop and add the functions of disaster prevention measures. This includes providing functions such as disaster risk assessment, early warning systems, emergency guidance, etc., to help users better understand the disaster situation and take appropriate preventive measures.

Future plans are to collate and document data for each disaster in more detail. We further study and analyze the occurrence rules, influencing factors and response measures of each disaster to enrich the contents of the database and provide more accurate and reliable disaster information. At the same time, we continue to improve the functions of the database, continue to meet the needs of users and provide more comprehensive and practical services in the future. As data accumulates and database functions continue to improve, we will conduct user testing and continuously optimize the database system based on user feedback to ensure that it is at the best level in terms of integrity and usability.

Conclusion

The purpose of this paper is to organize and analyze Japanese disaster-related data by establishing the spatial database of disaster time in Japan, exploring the regularity and trend of disaster occurrence, and providing a scientific basis for disaster prediction and prevention. We used techniques like deep learning, image processing, and databases to build a powerful database that includes detailed information about when, where, and what type of disaster occurred. Through the search function and map visualization of the database, users easily query and compare the frequency of disaster occurrence in different regions, and obtain detailed disaster information by clicking the mouse. This is of great significance for disaster prediction, prevention, and management, and has made positive contributions to academic research and cultural inheritance.

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Author contributions
LM is responsible for grasping and guiding the overall research structure, planning and guiding the research direction and objectives. BL is the builder of the system. She is mainly responsible for building the disaster database and website system. At the same time, BL was a major contributor to writing the manuscript. XY controlled and suggested the structure of the paper to ensure the logic of the paper and the coherence of the content. All the authors participated in the discussion and data collation during the research process, and the final paper was approved.

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Availability of data and materials
Our original data comes from Japan's official disaster data over the past year. The data set we are currently using is still in the refining stage, so it is not yet publicly available. We have successfully built a platform called "Japan Disaster Spatiotemporal Database System", but for now this system is only open to Ritsumeikan University insiders, and others cannot access it for the time being. We continue to work to improve this database system and look forward to further advances in data collation and analysis in the future. Once the dataset is ready and we ensure the integrity and accuracy of the data, we consider gradually making it available to the public so that more researchers and members of the public can share this valuable resource.

Declarations

Competing interests
The authors declare that they have no competing interests

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