Study on characteristic maps of multi-spectral remote sensing images of geological hazards

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Abstract. Geological disasters, as the main problems facing urban construction and development, directly threaten the life and property of social residents and living environment, with sudden, wide distribution, destruction and other characteristics. Nowadays, the traditional ground monitoring technology has been unable to meet the needs of geological disaster monitoring research in the new era. Therefore, on the basis of mastering the traditional monitoring experience, scholars from various countries put forward the use of multi-spectral remote sensing image data to obtain the data information of geological disasters in various regions, study the main causes and distribution rules of geological disasters, and put forward effective prediction models and solutions as soon as possible. On the basis of understanding the current situation of geological disaster monitoring and prevention work in China, this paper uses multi-source remote sensing image fusion technology to deeply study the multi-spectral remote sensing image feature map of geological disaster and clarify the relationship between different types of remote sensing image features, so as to provide effective basis for earthquake disaster monitoring and prevention work.

Keywords: Geological disaster; Multispectral; Remote sensing image; Characteristic map; Fusion technology.

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1. Introduction

In the process of development of modern society, the common geological disasters include debris flow, landslide, collapse, etc., which refers to the geological phenomena that the crust surface causes great damage to human life, property and ecological environment under the action of the earth's internal activities or external forces. Due to the complex geological structure, human life and movement more frequent, mining, soil erosion, vegetation destruction, etc.[1-3], have increased the probability and distribution range of geological disasters. At the same time, geological disasters are characterized by great danger, secrecy, and susceptibility. At present, traditional ground monitoring technology has been unable to meet the work needs, so some scholars put forward the use of remote sensing technology in their research. In essence, remote sensing has the characteristics of rapid, real-time and large-area monitoring. In the geological disaster monitoring work directly applied, no matter information extraction or rocker interpretation and translation has unique advantages, but it can provide basic functions such as data retrieval, data analysis, rapid mapping and data storage for practical research[4-6].

From the international point of view, the scholars of various countries can be divided into three stages in the study of geological disaster related topics: first, the embryonic stage. Before the mid-1970s, the research object of geological disaster was the national important project, and the number of practical research was small, mainly exploring the fundamental law of geological disaster occurrence and prevention measures. Second, the initial stage. From the mid-1970s to the late 1980s, the international geological disaster research has made excellent achievements, remote sensing technology has been fully used in monitoring research, which has a far-reaching impact on geological disasters. [7-9]Among them, the United States, Japan, India and European countries, when carrying out remote sensing monitoring work of geological disasters, not only master a wealth of technical theories, but also obtained high-quality experience in practical investigation. Most researchers began to use remote sensing technology to explore the quantity, location, distribution, characteristics and other contents of geological disasters, and gradually realized that the integrated development of remote sensing technology and geographic information system can help people have a deeper understanding of the relevant issues in the field of disaster prevention and reduction, and forecast and analyze the main factors and development laws of geological disasters. Finally, the stage of rapid development. In the 21st century, most scholars, based on the original research, mainly explore the vulnerability of geological disasters, practical management, and risk assessment. For example, some scholars believe that remote sensing technology is closely related to geological disasters after summarizing and analyzing the research methods of geological disasters, and some scholars believe that after integrating GIS and remote sensing technology, The feasibility and high precision of the two technologies are further verified in the study of geological hazards in mountainous areas.

From the domestic point of view, the research on geological disasters in China can be divided into three stages: first, from the early 1950s to the late 1980s, with the start of major national construction projects, more and more research topics related to geological disasters, and mainly focused on the event investigation, disaster distribution, prevention and control measures of these three aspects; Second, in the 1990s, China paid more attention to the study of geological disaster monitoring, evaluation, prevention and treatment, proposed the use of remote sensing satellite technology to quickly obtain real-time rich data information, and the use of GPS global positioning technology and remote sensing technology data analysis, data query, data management, data storage and other basic functions, comprehensive investigation and research. The problem of geological hazard; Third, since entering the 21st century, Chinese scholars have not only integrated and applied the functional advantages of various technologies, but also focused their research on the time, spatial distribution characteristics and evaluation model of geological disasters, and proposed to integrate and use advanced technology theories such as artificial intelligence, big data and cloud computing for verification and analysis. Therefore, this paper mainly uses multi-source remote sensing image fusion technology to study and investigate geological disasters, and studies and analyzes the characteristics and maps of typical multi-spectral remote sensing images of geological disasters, and finally defines the due role of relevant map information.[10-13]

2. Methods

2.1 Fusion Algorithm

In geological disaster investigation, due to the differences in research directions, there are a lot of data information to be stored and collected, and the basic geographic data formats are not uniform and the projection types are not consistent. Therefore, data resources should be processed integrally and converted into the same coordinate system. In this study, the collected data information is converted into the coordinate system projection mode to achieve accurate coordination within the space, and verification analysis is realized after the construction of the fusion data model. At the same time, remote sensing image processing software often used in geological disaster industry is used to carry out fusion experiment based on principal component analysis, wavelet transform, performance arithmetic and other methods. Spatial modeling tool is a goal-oriented model language environment, which can provide rich operators and functions, and generate data characteristics and application objectives suitable for users by using models. In this study, the IHS transform graph fusion mode is mainly chosen, and the specific fusion process is shown in Figure 1 below:[14-15]

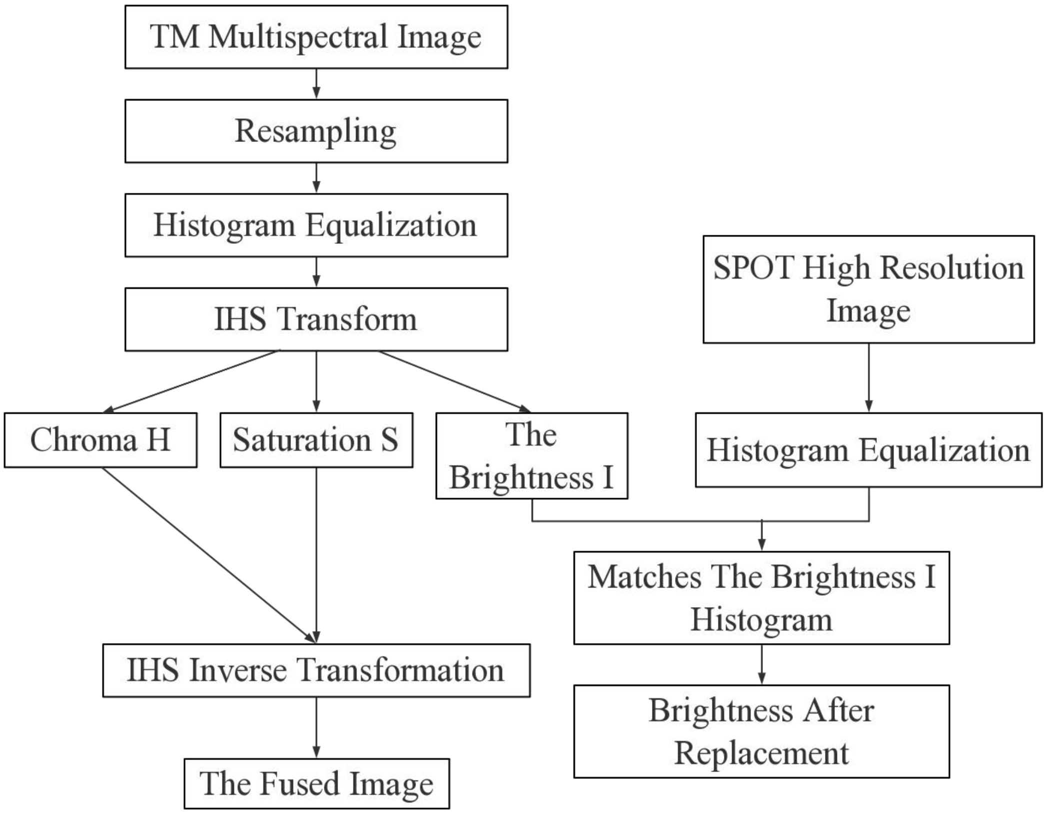

Figure 1. Flow chart of image fusion based on transformation

2.2 Quality Evaluation

Qualitative and quantitative methods can be used to evaluate and analyze the quality accuracy of remote sensing images. The former is judged and analyzed by studying visual effects, such as texture information, shape of ground objects, clarity, tone, etc., which is highly subjective. Therefore, it is an auxiliary tool in practical work. The latter will use statistical parameters and other data methods, is a common technical means of geological disaster prevention. In objective image quality evaluation methods, common data information involves the following points:

First, the variance. This information is mainly used to describe the degree of deviation from the average value. The larger the variance of the substituted image is, the higher the decomposition ability of the fused image is.

Second, the average gradient. This data information, also known as sharpness, directly reflects the tiny details, contrast and texture characteristics of the image. The higher the average gradient value, the clearer the fused image will be. The specific formula is as follows:

$$\bar{g}=\frac{1}{(M-1)(N-1)}\sum_{i=1}^{M-1}\sum_{j=1}^{N-1}\sqrt{\frac{(D(i,j)-D(i+1,j))^2+(D(i,j)-D(i,j+1))^2}{2}}$$

In the above formula, represents the gray value of the ith row and the JTH column of the remote sensing image, M represents the total rows of the remote sensing image, and N represents the total rows of the remote sensing image. Generally, the larger the value, the sharper the image.

Third, distortion. This evaluation index is mainly used to judge and analyze the amount of information contained in the original image and the fusion image, which can fully show the performance changes after the fusion of multi-source sensors. The specific formula is shown as follows:

$$D=\frac{1}{M\times N}\sum_{i}^{M}\sum_{j}^{N}\left|I_F(i,j)-I(i,j)\right|$$

In the above formula, IF (i, j) represents the gray value of the fused image at point (i, j), and I (i, j) represents the gray value of the original image at point (i, j). The smaller the distortion degree, the lower the possibility of proving the image distortion.

Fourth, the deviation index. This index directly shows the degree of spectral information matching between the fused image and the original image. These formulas are shown as follows:

$$D_k = \frac{1}{M \times N} \sum_{i}^{M} \sum_{j}^{N} \frac{\left| I_F^k(i,j) - L_k(i,j) \right|}{I_F^k(i,j)}$$

$$k = 1,2,3$$

In the above formula company, k represents the number of spectral bands, M×N represents the size of the fused image, $I_F^k(i,j)$ Represents the gray value of the fused image in K-band pixel (i, j), and Lk (i, j) represents the gray value of the original spectral image in K-band pixel (i, j).

Fifth, fidelity. This index is regarded as the degree of deviation between the evaluation image and the standard image. The larger the actual value is, the better the image improvement will be, and the actual fusion effect meets the expected requirements. The specific formula is as follows:

$$Corr(B,F) = \frac{\sum_{m=1}^{M} \sum_{n=1}^{N} \left[B(m,n) - \overline{B}\right]\left[F(m,n) - \overline{F}\right]}{\sqrt{\left\{\sum_{m=1}^{M} \sum_{n=1}^{N} \left[B(m,n) - \overline{B}\right]^2\right\}\left\{\sum_{m=1}^{M} \sum_{n=1}^{N} \left[F(m,n) - \overline{F}\right]^2\right\}}}$$

In the above formula $\overline{B}\overline{F}$ represents the average value of the corresponding image, showing the degree of correlation between the two images. The larger the actual value, the higher the correlation between the fusion image and the multispectral image.

3. Result analysis

3.1 Research Content

In this paper, a region for example, after mastering the image information related to geological disasters, through the panchromatic band and three multi-spectral band data fusion color image. After extracting remote sensing images of earthquake disaster target individual units, standard parameters and map information of different earthquake disasters are obtained through analysis and induction. The specific technical process is shown in Figure 2 below:

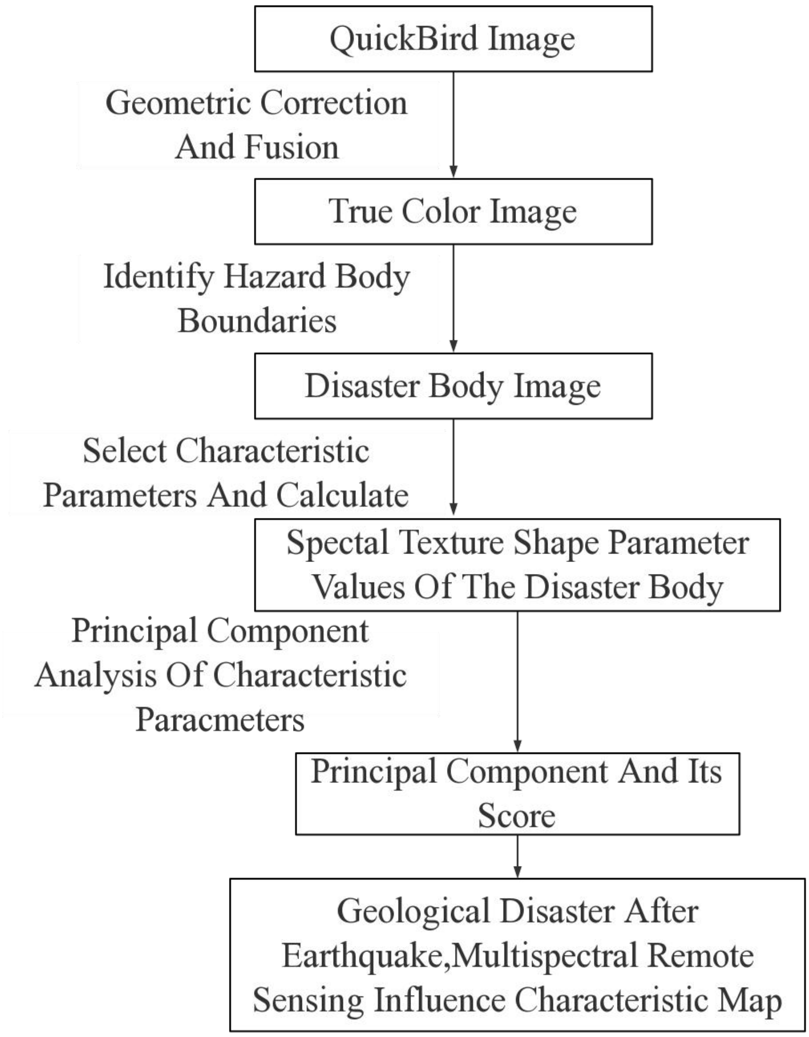

Figure 2 Technical flow chart

According to the analysis of the above figure, when establishing the map system, QuickBrid image data collected should be input into the system first. By identifying the edge of the earthquake disaster body, the characteristic parameters of the earthquake disaster body can be accurately calculated and standardized, and the characteristic map of multi-spectral remote sensing image of geological disaster can be finally obtained.

Combined with the combination relationship between the disaster body and the surrounding environmental factors, the main features of landslide, collapse and debris flow are judged by human-computer interaction, and relevant image features can be found as shown in Table 1 below:

Table 1 Analysis of various geological disasters and their features in remote sensing images

	landslide	collapse	Debris flow
Definition	Due to the influence of groundwater and surface water, the large rock (soil) on the slope slides down along the sliding surface under the action of gravity.	The phenomenon of separation from the slope along (such as weak structural planes such as bedding, joints, schistosity and fault plane) and sudden collapse.	The torrent containing a large amount of loose solid debris in mountain valleys often erupts in heavy rain or melting semester, with landslides or collapses at the source and debris flow accumulation fans at the downstream mountain pass.
Form	Generally, it is composed of landslide	Generally, it consists	Generally, it consists of formation zone, circulation

	body, landslide wall, sliding surface, landslide terrace, landslide bulge and landslide crack, and there are often landslide depressions and drunkards forests distributed on the landslide body.	of an upper collapsed back wall and a lower rockfill pile, and sometimes a plurality of rockfill piles are connected together to form a belt.	zone and accumulation zone.
Hue	It is grayish white, and there are often green vegetation on the landslide, and the edge is often relatively dark because of the enhancement of water content.	It is dark gray, gray or yellow-brown. The new collapse tone is light and the old tone is dark	Vegetation in the formation area is undeveloped, and the tone is light gray-gray. Gray deposits are common in the curved section of the groove in the circulation area, and the tone in the accumulation area is light gray-gray.
Shape	There are different shapes, the most typical one is the landslide body and the back wall, and the two side walls form a round chair shape. Others are tongue-shaped, arc-shaped, oval-shaped, bench-shaped, inverted pear-shaped, horn-shaped, parallelogram-shaped, diamond-shaped, leaf-shaped, shingle-shaped, horseshoe-shaped, spoon-shaped, shovel-shaped, irregular, etc.	Irregular patches such as blocky, slender fan-shaped or linear patches, steep cliffs and precipices with linear or arc shape developed at the rear edge of the collapse body, and one or several groups of joints are common at the top of the wall, which are serrated in plane.	Most of the formation areas are spoon-shaped, funnel-shaped, floating, elliptical, etc., surrounded by mountains on three sides, and the grooves in the circulation area are wide, narrow and straight, mostly flat, dendritic wandering river sections or trunk ditches, The accumulation area is often fan-shaped with clear outline but not fixed.
Vein	The surface texture of landslide accumulation body is rough, and the back wall of landslide is smooth and delicate.	The overall image texture is rough, and there are many rough feelings or mottled conical textures below the cliff.	Uniformly distributed granular and speckled texture, the straight section of the groove has the characteristics of scouring image, lacking deposits, and slightly flowing texture on the high-resolution image.

When extracting the image of the disaster body, visual interpretation should be used to outline and cut the boundary of the disaster body, and then eCognition software should be used to achieve multi-scale image segmentation and merging, and finally facilitate the statistics of the spectral, shape, texture and other characteristic values of the disaster body object. In the research experiment of this paper, there are 20 selected characteristic parameters. In order to facilitate unified processing, principal component analysis should be carried out. Finally, the content shown in Table 2 can be obtained:

Table 2 Comparison results of characteristic values and contribution rates

principal constituent	eigenvalue	Contribution rate/%	Cumulative contribution rate/%
y1	10.9504	54.75	54.75
y2	4.9371	24.69	79.44
y3	1.8520	9.26	88.70

Meanwhile, the load analysis results of principal components are shown in Table 3 below:

Table 3 Load analysis results of principal components

Feature name	a1	a2	a3
DN value of red light band	0.2658	-0.1347	-0.2604
DN value of green band	0.2493	-0.1829	-0.2692
DN value in blue band	0.2233	-0.2201	-0.2880
brightness	0.2482	-0.1733	-0.2775
maximum deviation	-0.2717	-0.0032	0.1907
length-width ratio	0.2499	0.1012	0.2492
asymmetry	0.2281	0.1001	0.3175
Quasi-ellipticity	-0.2842	-0.0335	-0.2004
Quasi-rectangle degree	-0.2846	-0.0083	-0.1771
Compactness	0.2649	0.0464	0.2215
Boundary index	0.2725	0.0501	0.2413
Shape index	0.2748	0.0670	0.2512
homogeneity	-0.0580	-0.3900	0.2577
contrast	0.2197	-0.1862	0.1135
diversity	0.1936	0.2102	-0.1425
entropy	0.0808	0.4152	-0.1847
Angular second moment	-0.0050	-0.4124	0.1551
average value	0.2439	-0.1906	-0.2865
standard deviation	0.1646	0.2695	-0.0359
correlation	-0.0205	0.3961	-0.1319
Note: The bold parts indicate the variables that contribute the most.			

Combined with the data information obtained in the above table, it can be seen that the genealogy of landslide, collapse and debris flow is obviously different. By analyzing the first component of the shape characteristic, the score of the first principal component of the debris flow is higher, while the score of the other two components is lower. The third component of disorder can effectively distinguish between landslide and collapse, and the former has a higher principal component score and more abundant texture information. The analysis results of the second principal component of the texture show that the spectrum of the detritus flow map is widest here, which proves that this texture feature has diversity, while the value range of landslide is relatively large, and the actual texture feature is very obvious.

4. Conclusion

To sum up, as one of the countries with serious geological disasters, casualties and economic losses are becoming more and more serious. Therefore, when studying ground survey schemes and modern science and technology, scholars put forward multi-source remote sensing image fusion technology, which aims to change the traditional ground survey management mode and fully demonstrate the application advantages of remote sensing technology. The characteristic maps of multi-spectral remote sensing images of geological disasters are deeply explored to better meet the needs of practical work. At the same time, when studying the characteristic maps of multi-spectral remote sensing images of geological disasters, we should learn from advanced technologies and experimental methods proposed abroad, pay attention to the optimization and innovation combined with the basic national conditions of our country, so as to put forward more appropriate investigation schemes and application technologies, and scientifically solve the adverse effects of geological disasters.

References

[1] Yujia Zhang, Wanpeng Zhou, Zhensen Zhang, Yongfeng Li, Mingkun Li. Characteristics and causes of geological hazards in Cuiheng New District based on GF-1 Remote sensing and GIS data [J]. Journal of University of South China (Natural Science Edition), 2021, 035(006):24-28,34.

[2] Huaping Zhang, Xiangyuan Liu. Application of remote sensing image technology in geological disaster emergency mapping service [J]. China Metal Bulletin, 2021(24):146-148.

[3] Wenxi He, Chen Sun, Zongmin Yin, et al. Prediction system of geological hazard change situation in mining area based on multi-source remote sensing data [J]. Automation & Instrument, 2022(008):000.

[4] Guangzhou Liang. Application of remote sensing mapping technology in geological disaster monitoring and management [J]. Engineering Technology Research, 2021, 3(7):77-78.

[5] Lirui Yun. Application and innovation of remote sensing survey in geological disaster management [J]. Geology and Ore Surveying and Mapping, 2021, 4(2):76-77.

[6] Zhuang Li, Bin Li, Yang Gao, et al. Remote sensing interpretation of geological hazard development characteristics in upper Sedongpugou in the lower reaches of Yarlung Zangbo River [J]. Chinese Journal of Geological Hazard and Control, 2021, 32(3):9.

[7] Guanjun Hu, Wei Dang, Mengdi Jin, et al. Application of WV-3 Remote sensing data in Mineral resources development and geological disaster investigation in western Yunnan [J]. Chinese Journal of Geology, 2022(002):046.

[8] Jingtao Liang, Cong Zhao, Zhigang Ma. Application of multi-source Remote sensing technology in early identification of geological hazards: A case study of Southwest mountainous area [J]. Geological Survey of China, 2022(004):009.

[9] Wen Liu, Meng Wang, Sainan Zhu, et al. Analysis of chain characteristics of high geological hazards in high mountains and extremely high mountains based on optical remote sensing technology: A case study of typical Jiang-blocking landslide in the upper reaches of Jinsha River [J]. Chinese Journal of Geological Hazard and Control, 2021, 32(5):11.

[10] Weihu Guan. Research on Remote Sensing interpretation and identification method of geological hazard hidden points in Gangu County based on ArcGIS [J]. Chinese Science and Technology Journal Database (full-text edition) Natural Science, 2021(4):2.

[11] Jun Li, Hongliang Chu, Bin Li, et al. Development characteristics of high level chain geological hazards in Zelongnong, Nyingchi, Tibet based on high-resolution image and InSAR interpretation [J]. Chinese Journal of Geological Hazard and Control, 2021, 32(3):9.

[12] Shizhong He, Lei Shi, Chengfeng Zhou, et al. Geological hazard risk investigation and evaluation in Jing County, Anhui Province (1:50000) [J]. Geology of Anhui, 2022(002):032.

[13] Tao Duan. Image recognition of landslide geological disaster based on UAV low altitude remote sensing [J]. Energy Technology and Management, 2022, 47(4):2.

[14] Xinjian Ma, Yingfei Xiong. Discussion on the characteristics of geological hazards in Chancheng District of Foshan City [J]. Gansu Water Resources and Hydropower Technology, 2021, 57(5):4.

[15] Tiantian Zhang, Yueping Yin, Bin Li, et al. Types and development characteristics of geological hazards in the upper part of Bomi Chalonglong Baqu in Xizang Province [J]. Chinese Journal of Geological Hazards and Control, 2021, 32(3):8.