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Retraction

Retracted: Application of Road Extraction from High-Resolution Remote Sensing Images in Tourism Navigation and GIS

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] G. Wang, C. Ma, and X. Liang, "Application of Road Extraction from High-Resolution Remote Sensing Images in Tourism Navigation and GIS," *Wireless Communications and Mobile Computing*, vol. 2022, Article ID 2422030, 8 pages, 2022.

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Research Article

Application of Road Extraction from High-Resolution Remote Sensing Images in Tourism Navigation and GIS

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In order to quickly and accurately obtain and process road information and its damage information, to obtain better tourism navigation experience and accurate geographic information, this paper proposes a road extraction method based on high-resolution remote sensing images. Based on the known road width information and the analysis of the gray-scale characteristics of the road surface, the method takes the road center line and straight line in the image as the center line and then deduces the road edge line information, so as to extract the edge information. Then, through the image de redundancy information processing, the final obtained road width parameters are compared to verify the accuracy and reliability of the method. The experiment shows that the road information can be extracted accurately, and the extraction accuracy and efficiency have been significantly improved, reaching more than 90%, and can directly reflect the road edge line, median line, and width information. *Conclusion*. The road extraction method based on high-resolution remote sensing images can effectively and accurately extract road information, obtain better tourism navigation experience, and accurate geographic information.

1. Introduction

With the rapid development of information technology and sensor technology, the resolution of satellite remote sensing images (including spatial resolution, spectral resolution, and temporal resolution) has been greatly improved. Since the first earth observation satellite with a resolution of was launched in, it has been developed into a high-resolution remote sensing satellite with an order of magnitude or below, and the resolution is getting higher and higher [1]. With the application of high-resolution remote sensing images, we can obtain more accurate, richer, and more comprehensive information. Extracting information from remote sensing images, obtaining information by identifying interested targets and completing image understanding are the fundamental goals of remote sensing applications [2]. Road information is a very important part of the information that remote sensing images can provide. Transportation-related industries play an important role in the national economy and people's lives. In geographic information science, roads have always been an important research direction of related disciplines because of their obvious regional characteristics. With the development of remote sensing and its related technologies, they have been inseparable with electronic technology, communication technology, computer technology, and information science, making the research on road traffic more automatic and intelligent. From urban road planning to road congestion detection, tourism navigation, and geographic information application, all reflect the great role of road information. However, with the continuous updating of road information, the traditional manual operation has been unable to meet the demand. Therefore, combining remote sensing technology with electronic technology and image recognition technology to study the extraction of roads from remote sensing images can improve efficiency, which is of great significance for road monitoring, navigation, and timely updating of maps. At present, the diversity of information sources and the explosive growth of the amount of information have led to great changes in our research methods and means [3]. Now people increasingly rely on the unified research level, large professional databases, and the efficient retrieval and organization of a large amount of information. The use of computer technology to extract and sort out the data information of massive literature and establish a professional database with specific standards can provide effective means for information extraction, processing, and organization [4]. Therefore, it is very important to extract roads from high-resolution remote sensing images. How to quickly and accurately obtain and process road information and its damage information is the top priority. This paper makes an in-depth study on road vector extraction from high-resolution remote sensing images.

2. Literature Review

As for the research on road extraction from high-resolution remote sensing images, Kang et al. proposed a method based on polyphase time, which is to compare the photos at different time points before and after the road damage and analyze and extract the road damage information. Using the correlation coefficient method, through the correlation analysis of the image road information before and after the road damage, the geometric information and attribute information of the road damage are obtained [5]. Ma et al. proposed an interpolation method to compare road extraction [6]. The difference method is to extract the road from the registered image of the same area, then perform the difference operation to obtain a difference change image, and then analyze, judge, and extract the change information. However, this method is vulnerable to the noise and pixel gray value changes when obtaining the image. Li et al. proposed a single-phase change detection method. For the change detection of object features, first use professional software to segment the image, then extract the spectral features, texture features, and shape features of the segmented target object, respectively, use the difference method for change detection, and finally fuse the change detection results of different object feature levels to obtain the final results [7]. Jones and Renwick proposed a road classification and comparison method. The postclassification comparison method is a very intuitive change detection method. It requires that each image be classified separately, and then, the classification result images of multitemporal images are compared to detect the change information of the ground objects of interest and can also provide the change type information [8]. Ajay et al. proposed to use relatively parallel edges to select seed points and connect them according to the similarity of edge strength and length. At the same time, they made use of the system of opportunity rules. This method simply assumes that there is no noise in the image, and the road has a high contrast with the background, so its adaptability is not high [9]. Guo et al. proposed and designed a relatively complex system for road extraction on textured aerial images. This is a multilevel structure, so that low-level processing and high-level processing can cooperate with each other [10]. The low-level processing uses the method of section matching. The high-level processing can obtain the vehicle information of intersection, gland, width change, and road surface. If there is an interruption, a new model can be generated to continue the road tracking.

On the basis of current research, this paper proposes a road extraction method based on high-resolution remote sensing images. Based on the known road width information and the analysis of the gray-scale characteristics of the road surface, the method takes the road center line and straight line in the image as the center line and then deduces the road edge line information, so as to extract the edge information. Then, through the image de redundancy information processing, the final obtained road width parameters are compared to verify the accuracy and reliability of the road extraction.

3. Research Methods

3.1. Basic Framework of Road Information Extraction. Road damage information extraction is a comprehensive method of road extraction and road damage detection. The knowledge involved in the research of road information extraction is not only the extraction and positioning of high score image targets, but also the analysis and interpretation of the extracted targets and the comprehensive understanding of road knowledge information. Road information extraction is to select appropriate methods to extract accurate road information based on the full analysis of road feature information. Road damage information is based on road information extraction to deeply analyze road targets. Road damage information extraction is the change of corresponding information on high score images before and after road damage, and it is the change detection of specific targets [11, 12].

3.1.1. Road Feature Analysis. The road in the remote sensing image presents bright or dark strip features that are obviously different from the geometric shape of the background. Asphalt roads generally show a dark strip shape in high-resolution remote sensing images. Concrete, gravel, and soil pavements generally show a bright strip shape. Intersections are generally shown as light and dark areas with different shapes, such as cross, T-shaped, circular, and butterfly. The pavement marking lines are generally bright short lines and long lines. The urban road presents the complex network characteristics of horizontal and vertical staggered and cross connected in its topological characteristics; But the nonurban road presents a simple network feature. The background of urban roads is generally complex background such as buildings, roadside trees, and isolation belt between roads [13]. The background of nonurban roads, especially expressways, is generally simple background such as farmland, mountain forest, or river, and there is a linear isolation belt in the middle of the road. Through the analysis of the characteristics of roads in high-resolution remote sensing images, combined with the characteristics of roads in the real world, road pavement materials, and image performance, and through the analysis of road attributes to connect the characteristics of roads in all levels, scholars have established classic road models, as shown in Figure 1 below.

The model summarizes the characteristics and corresponding relationships of roads in the three levels. It highlights the characteristics, existing forms, and material characteristics of roads in different levels and provides clear guidance and strong support for road idea extraction in remote sensing images. Image features are composed of physical features, geometric features, and gray-scale change features of local areas. The region with features contains a large amount of information, while the region without features should only contain a small amount of information [14]. Roads have the following characteristics in remote sensing images:

(1) *Geometric Features*. Roads appear in the image in the form of long strips with little change in curvature. The width of the road changes little and is far less than its length. The intersections and overpasses of roads are polygonal areas with certain characteristics in a large area.

(2) *Radiation Characteristics*. The gray value of the road image is relatively single within the two edge lines, has certain texture characteristics, and has a large difference with the pixel gray value of its adjacent areas, forming a clear contrast.

(3) *Topology Features*. Generally, roads do not exist alone. They are usually connected with other roads to form a road network and will not be disconnected in the middle. In the image, one end of the road is either connected with other roads or extends beyond the image.

(4) *Context Characteristics*. It is the image feature information of the areas closely related to the road, such as the roadside trees and buildings on both sides of the road, the lane, zebra crossing, and various driving signs on the road on the high-resolution image, as well as the material properties of the road, which are all the context information of the road [15].

As the resolution of remote sensing image is getting higher and higher, the details provided by the image are becoming richer and richer. For example, narrow roads that could not be distinguished in the previous medium and low-resolution images can now be clearly distinguished [16]. However, while improving the resolution brings rich detail features, it also brings a large number of noise information of nontarget objects, which also causes two main problems in the process of extracting the road network: first, the buildings around the road and the road have very similar light reflection characteristics, resulting in similar strip and gray-scale features in the image. Even after the region segmentation, the two cannot be clearly separated. Second, the high-resolution image not only enriches other details of the image but also enriches the detailed features of the road surface, making the vehicles, pedestrians, and trees on the road surface clearly visible, resulting in the road surface becoming mottled and fractured fragments in the image, so that the extraction method based solely on the road texture feature is no longer applicable to those urban roads and roads with rich road information, increasing the difficulty of road network extraction [17].

3.1.2. Characteristic Analysis of Road Damage Information

(1) Changes in Geometric Characteristics. Because the roadbed and pavement are damaged or covered by a large amount of deposits, the regular geometric features of the road image on the high-resolution image change or even disappear. The spatial continuity is damaged, and the intact road and the damaged road are spaced. The edge line characteristics of the road are damaged. The complete road is two continuous and clear edge lines, while the damaged road has only one discontinuous edge line or both edge lines disappear. The structural structure of the road is damaged by the strong earthquake, which will cause the fluctuation of the road surface, change the width of the road surface, partially narrow or completely covered, and change the extension direction of the road [18], as shown in Table 1.

(2) Spectral Characteristic (Gray Scale) Change. The material and reflectivity of pavement determine the spectral characteristics of pavement. The damage of the pavement caused by strong earthquakes will change the smoothness of the road surface or produce large cracks or be covered by rocks, trees, snow, and other debris, resulting in changes in the light reflection characteristics of the pavement, thus changing the characteristics of the road in the high-resolution image. The changes are mainly reflected in the following aspects: first, the characteristics of the uniform gray scale and texture of the road are changed, becoming disordered or even disappearing. Second, the physical structure of the pavement and subgrade is damaged, which reduces the image gray of the road. However, the pavement accumulation caused by secondary disasters such as landslides and debris flows makes the gray and texture of the road image closer to the spectral characteristics around the road [18].

(3) Topology Characteristic Change. Strong earthquakes will cause "broken roads" and "isolated roads" and destroy the topological characteristics of the original intact road network-connectivity and connectivity.

(4) Contextual Characteristics. Landslide and debris flow caused by secondary disasters can provide reference information for road damage information extraction. The break and disappearance caused by the shadow and occlusion of buildings, trees, and viaducts can also be used as reference information for road extraction.

3.2. Road Extraction Based on Vector Template. To extract the road image, we need to do some pretreatment to make it meet the requirements of the road extraction method.

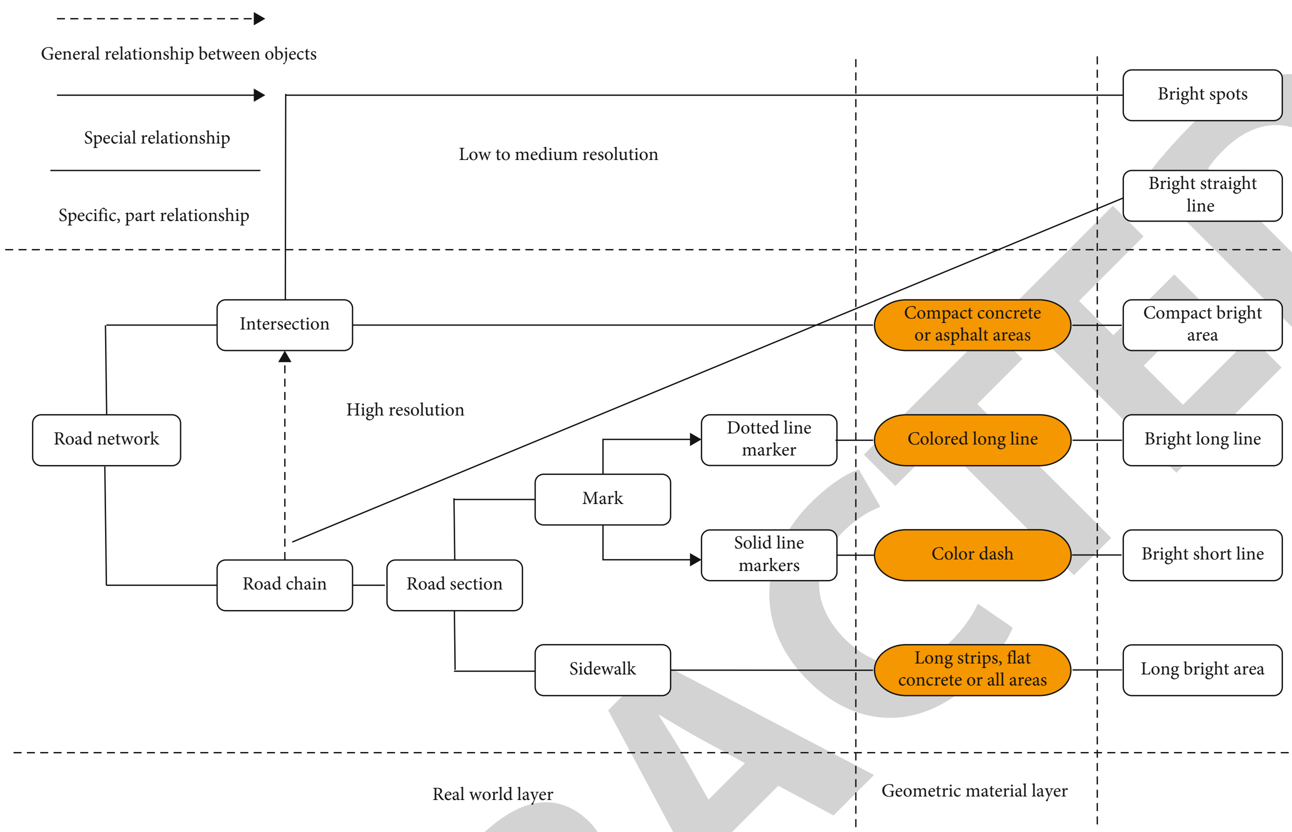


Figure 1: Classic road model in optical image.

Table 1: Disaster change of geometric characteristics of road boundary.

Geometric features	Preearthquake road	Postearthquake road
Continuity	The edge has good continuity without interruption	Edge line intermittent
Parallelism	The road has two parallel side lines, and the lane or separation zone of the high-grade road is also parallel to the road side line	The edge lines of the damaged road are not parallel, and one or two of the edge lines change or even disappear
Width	The width change along the road is very small. The width is related to the grade of the road. The higher the grade, the greater the width	The structural damage and the covering of deposits will cause sudden changes in width

The technical scheme of pretreatment process is shown in Figure 2 below.

Image correction: during image acquisition, the image cannot be kept strictly horizontal, and the ground is not completely horizontal, so the image will produce deformation errors such as image point displacement, graphic deformation, and inconsistent scale. Therefore, in order to extract accurate road information, it is necessary to correct the images obtained by remote sensing. Because the road information extraction we are going to carry out has higher requirements for the accuracy of the image, we need to carry out necessary image correction so that the road information on the image can accurately reflect the real data information of the road, including road direction, width, length, edge line, and other information. Image registration: because the extraction of road damage information we need to do is based on high-score images of the same area at different time points, we need to do some registration work to make the two (more) images match completely, so as to extract different road information before and after the road damage, and then compare and extract the road damage information. As the methods used for image registration and correction are not the main research content of this paper, the existing mature registration and correction methods are used to ensure the accuracy and reliability of road damage information extraction [19].

On the basis of image information enhancement, we remove the redundant information, mainly the nonroad objects in the image. After binarization and mathematical morphology processing, the road information can be clearly displayed on the image, but there are still some noise effects in some areas. Let us solve this problem by opening and closing operations. First, we set a strip operator with the same width as the road span. This operator can simply rotate around the center of the strip operator, and the rotation is

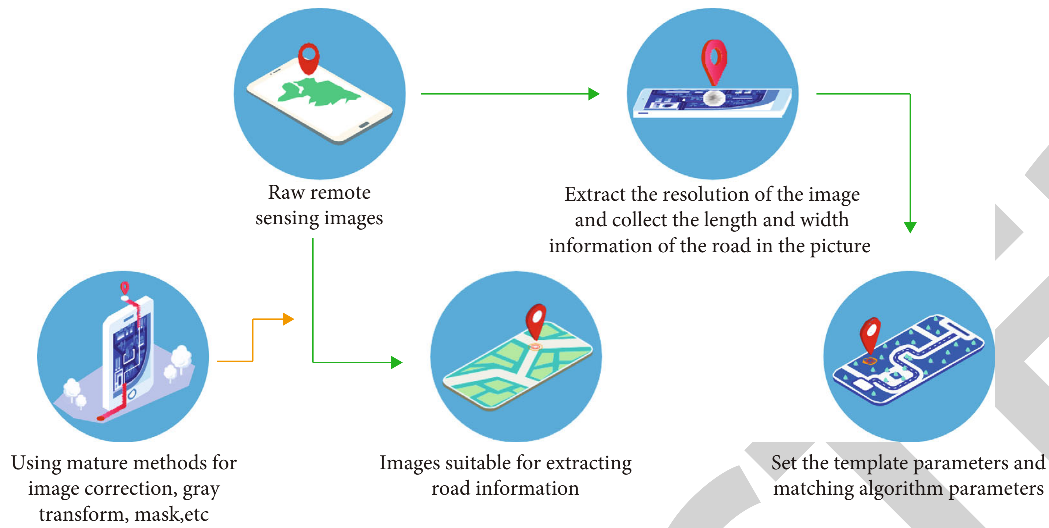
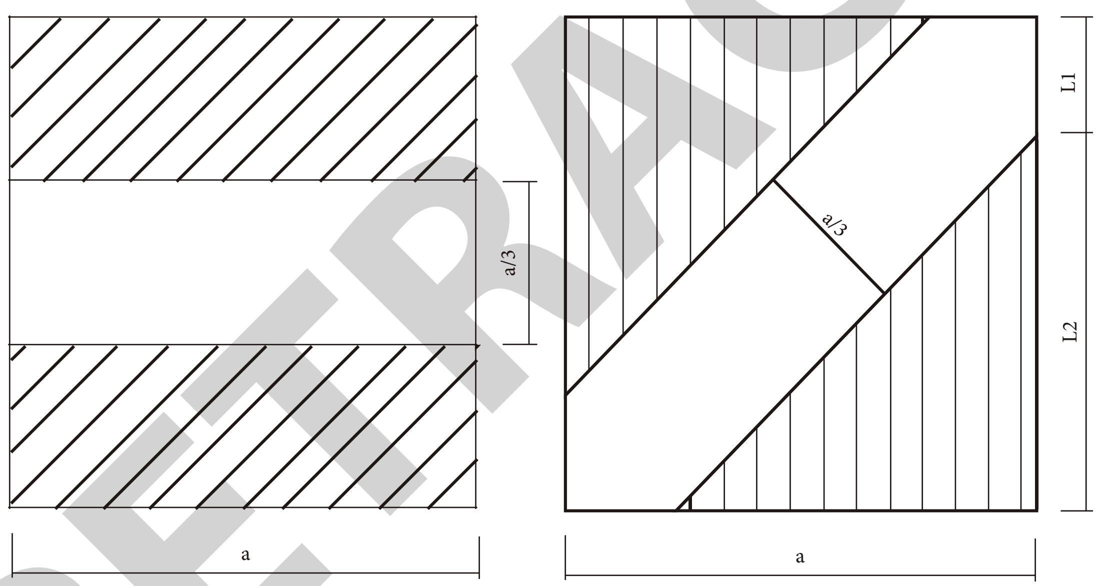


FIGURE 2: Pretreatment process technology scheme gap.



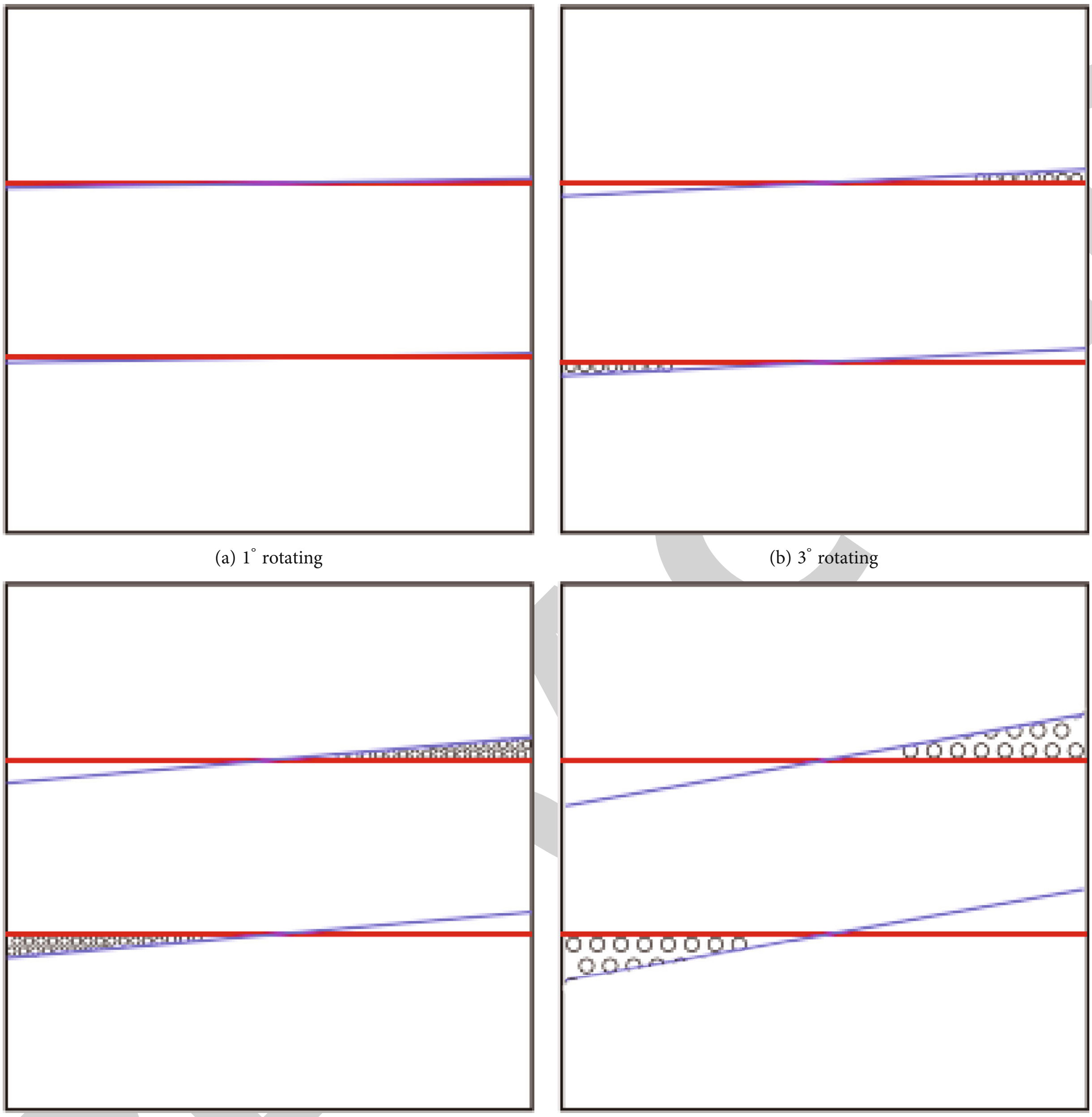
(a) The smallest proportion (b) The largest proportion

FIGURE 3: Scale analysis.

limited to 90°, that is, rotate 45° left and right in the vertical direction, so as to find out the area where the "vertical" road exists. Then, we set a horizontal strip operator, which can rotate 45° up and down in the horizontal direction, so as to find out the area where the "horizontal" road exists. In this way, adding the road existence regions in the two directions can obtain the road existence regions in the "all directions," so that the next step of vector template matching can be done to extract road information [20].

In the actual operation, the road vector template is built in the search box, its rotation is completed within the boundary of the search box, and its movement is carried out with the movement of the search box. The feature analysis of pixels in the search box is the basic analysis of template matching. The following is an analysis of the characteristics of pixels inside the search box:

First of all, the search box is a square window three times the width of the Road W. Its internal points are composed of pixel points in the image, which can be regarded as a $3w * 3w$ matrix. The value of each point is the gray value of the pixel points, which requires us to analyze the data in the search box to see whether there are road segments, as shown in Figure 3 below. Suppose the width of the search box is a, then the road width in the search box is $a/3$. Calculate the proportion of the blank part in the figure to the total area of the search box, that is, the proportion of road pixels in the search box to the road pixels and the total pixels in the box [21].



(a) 1° rotating (b) 3° rotating

(c) 5° rotating (d) 10° rotating

Figure 4: Simulation diagram of different rotation angles.

We assume that the area of the search box is s, the blank area is s, and the ratio of the blank area to the total area of the search box is Nmax, then

$$\eta_{\min} = \frac{S_{1空}}{s} = 0.33,$$
$$\eta_{\max} = \frac{S_{2空}}{s} = 0.4158. \tag{1}$$

The result of the above two formulas is the area proportion relationship between the road section and the search box in the model. Because each pixel in the digital image is also closely connected, this proportion can also represent the proportion between the number of pixels in the road section and the number of all pixels in the search box. Therefore, we can conclude that only when the number of pixels of a certain gray value (gray value of road pixels) in the search box reaches a certain proportion, it can indicate that the search box may contain road segment information. In this way, the search matching range can be greatly reduced and the operation time can be greatly reduced. Due to the influence of noise in the actual high score image, the scale range should be adjusted appropriately. We set the threshold

Table 2: Comparison between experimental data and actual data.

Project	Actual specified width road length m	Road length m of specified width extracted by experiment	Extracted scale
All designated roads	5055.40	4550.41	90.1%
Specify the straight portion of the corridor	3341.7	3131.77	93.71%

value between 0.3 and 0.45 according to multiple checking calculations, which can eliminate part of the influence caused by noise and gray value setting error. Because the roads may exist at any angle in the image, the template must adapt to the road matching of each angle, which leads to the problem of the rotation angle gradient of the road template, as shown in Figure 4 below.

We analyze the extracted matrix to be analyzed (search box suspected of containing road information). Any point $o(x, y)$ in the matrix that meets the set road gray threshold, if $f_{L2}(x) < y < f_{L1}(x)$, means that the suspicious point is in the road template. After all the suspicious points are analyzed, we record the total number of suspicious points in the road template and then compare this value with the total number of pixels in the road template. If the ratio road is a large value (above 0.8), we can determine the angle, position, center line, edge line, and other information of the road in the search box. This completes the work in this search box. Carry out the remaining matrix to be analyzed in turn, and you can find all the roads that meet the requirements.

4. Result Analysis

Taking the high score image of the main road in an urban area as an example, the road extraction experiment is carried out. The image size is 4077×4092 pixels, and the resolution is 0.2 meters. There are two roads with known width in the area. We select a road with the same pavement gray and 12 m width as the extraction object, that is, the road width in the image is 60 pixels. In order to make the template better cover the road and adapt to the search box calculation, we set the extracted width value to 61 pixels. Based on the known road width information and the analysis of the gray-scale characteristics of the road surface, the center line and straight line in the closest image are taken as the center line, and then, the road edge line information is derived. In this way, the extracted edge information is more accurate than the center line information and can also provide more accurate basic information support for the extraction of road damage information, as shown in Table 2.

Through the experiment, we can see that it is feasible to extract the road information of the specified width in the high score image by using the vector template matching search method and can also get good results, which can meet the requirements of extracting the road damage information for line scanning. The road information can be extracted accurately; the accuracy and efficiency of extraction have been significantly improved and can directly reflect the information of road edge line, median line, and width.

5. Conclusion

In this paper, a road extraction method based on high-resolution remote sensing image is proposed. Based on the known road width information and the analysis of the gray characteristics of the road surface, the center line and straight line in the image are taken as the center line, and then, the road edge line information is derived to extract the edge information, and then, the final road width parameters are compared through image de redundancy information processing. The experiment shows that the road information can be extracted accurately; the extraction accuracy and efficiency have been significantly improved, reaching more than 90%, and can directly reflect the road edge line, median line, and width information. It can be verified that this method can effectively and accurately extract road information and can obtain better tourism navigation experience and accurate geographic information.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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References

[1] G. Pan, L. Fu, Q. Chen, M. Yu, and M. Muresan, "Road safety performance function analysis with visual feature importance of deep neural nets," *IEEE/CAA Journal of Automatica Sinica*, vol. 7, no. 3, pp. 112–121, 2020.

[2] A. Abdollahi, B. Pradhan, and A. M. Alamri, "Vnet: an end-to-end fully convolutional neural network for road extraction from high-resolution remote sensing data," *IEEE Access*, vol. 8, pp. 179424–179436, 2020.

[3] A. Sharma and R. Kumar, "Risk-energy aware service level agreement assessment for computing quickest path in

computer networks," *International Journal of Reliability and Safety*, vol. 13, no. 1/2, p. 96, 2019.

[4] M. Raj, P. Manimegalai, P. Ajay, and J. Amose, "Lipid data acquisition for devices treatment of coronary diseases health stuff on the internet of medical things," *Journal of Physics: Conference Series*, vol. 1937, no. 1, article 012038, 2021.

[5] L. Kang, G. Hu, H. Huang, W. Lu, and L. Liu, "Urban traffic travel time short-term prediction model based on spatio-temporal feature extraction," *Journal of Advanced Transportation*, vol. 2020, Article ID 3247847, 16 pages, 2020.

[6] L. Ma, Y. Li, J. Li, J. M. Junior, and M. A. Chapman, "Boundarynet: extraction and completion of road boundaries with deep learning using mobile laser scanning point clouds and satellite imagery," *IEEE Transactions on Intelligent Transportation Systems*, vol. 99, pp. 1–17, 2021.

[7] Y. D. Le Li and X. Liu, "Ce-Mn mixed oxides supported on glass-fiber for low-temperature selective catalytic reduction of NO with NH3," *Journal of Rare Earths*, vol. 32, no. 5, pp. 409–415, 2014.

[8] J. Jones and M. E. Renwick, "Mapping southern spoken dialect features with geographic information systems," *The Journal of the Acoustical Society of America*, vol. 148, no. 4, pp. 2471–2471, 2020.

[9] P. Ajay, B. Nagaraj, R. A. Kumar, R. Huang, and P. Ananthi, "Unsupervised hyperspectral microscopic image segmentation using deep embedded clustering algorithm," *Scanning*, vol. 2022, Article ID 1200860, 9 pages, 2022.

[10] E. Guo, V. Jagota, M. Makhatha, and P. Kumar, "Study on fault identification of mechanical dynamic nonlinear transmission system," *Nonlinear Engineering*, vol. 10, no. 1, pp. 518–525, 2021.

[11] A. Nt and B. Eda, "Linking OpenStreetMap with knowledge graphs — link discovery for schema-agnostic volunteered geographic information - sciencedirect," *Future Generation Computer Systems*, vol. 116, pp. 349–364, 2021.

[12] X. Liu, "The application of deep convolution neural network to building extraction in remote sensing images," *World Scientific Research Journal*, vol. 6, no. 3, pp. 136–144, 2020.

[13] A. Abdollahi, B. Pradhan, and N. Shukla, "Road extraction from high-resolution orthophoto images using convolutional neural network," *Journal of the Indian Society of Remote Sensing*, vol. 49, no. 3, pp. 569–583, 2021.

[14] S. Zheng, J. Shi, X. Wang, X. Fu, H. Fan, and H. Zhang, "Flexible thermosensitive films based on shallow-trap persistent luminescence for high-resolution texture imaging of fingerprints even through latex gloves," *Journal of Materials Chemistry C*, vol. 9, no. 30, pp. 9619–9626, 2021.

[15] P. Kurtakoti, M. Veneziani, A. Stssel, W. Weijer, and M. Maltrud, "On the generation of Weddell Sea polynyas in a high-resolution earth system model," *Journal of Climate*, vol. 34, no. 7, pp. 2491–2510, 2021.

[16] L. Wang, H. Zhou, W. Liu, B. Yu, and S. Zhang, "High-resolution seismic acoustic impedance inversion with sparsity-based statistical model," *Geophysics*, vol. 86, no. 2, pp. U1–U13, 2021.

[17] I. Bejleri, X. Xu, D. Brown, S. Srinivasan, and N. Agarwal, "Automatic horizontal curve identification for large areas from geographic information system roadway centerlines," *Transportation Research Record*, vol. 2675, no. 12, pp. 1088–1105, 2021.

[18] M. H. Nguyen, J. Armoogum, and E. Adell, "Feature selection for enhancing purpose imputation using global positioning system data without geographic information system data," *Transportation Research Record*, vol. 2675, no. 5, pp. 75–87, 2021.

[19] X. Li, Z. Zhang, S. Lv, M. Pan, and H. Yu, "Road extraction from high spatial resolution remote sensing image based on multi-task key point constraints," *IEEE Access*, vol. 9, pp. 95896–95910, 2021.

[20] J. Zhao, S. Liu, J. Wan, M. Yasir, and H. Li, "Change detection method of high resolution remote sensing image based on D-S evidence theory feature fusion," *IEEE Access*, vol. 99, pp. 4673–4687, 2020.

[21] G. Veselov, A. Tselykh, A. Sharma, and R. Huang, "Special issue on applications of artificial intelligence in evolution of smart cities and societies," *Informatica (Slovenia)*, vol. 45, no. 5, p. 603, 2021.