Dynamic identification of coastal climate characteristics and traditional residential space design based on multi-source remote sensing images

Shangcao Li¹ · Jae Chul Park¹ · Tianlong Chai¹ · Xuesong Gao¹

Abstract
In this article, the author gives a detailed introduction to the establishment of the target feature database of the multi-source remote sensing image area. When building the target feature database, the target must be extracted first. There are many studies in this area, so the author focuses on how to extract high-resolution image targets and introduces the types of target features and how to extract common target features. Nowadays, the research of multi-source remote sensing technology has made significant progress, and people have begun to invest in the research of remote sensing image atmospheric climate correction methods. The sensor will obtain more imaging information, but not all of this information comes from the target features. In addition, the information obtained is also affected by atmospheric molecules, and the contrast is greatly reduced. The data obtained in this way is not even after processing able to achieve the target accuracy. In order to solve the problem of the decrease of matching degree due to the nonlinear change of gray value, the author proposes a new feature point matching algorithm, which uses spectral information when fitting remote sensing image bands. With the development of economy, people have new requirements for the living environment. When designing space, designers should pay more attention to the sense of experience. In this article, the author analyzes the space design of traditional houses. When designing traditional dwellings, it is often necessary to combine local traditional dwelling resources to create a better experience for customers, so that traditional dwelling resources can give full play to their functions, expand influence and open up visibility while meeting consumer needs, promote the development of the local tourism industry, and bring economic benefits to the local area.

Keywords Multi-source remote sensing images · Atmospheric climate · Traditional houses · Space design

Introduction
With the advancement of people’s research in satellite and sensor technology, new results have been made in sensor research, and sensors can obtain more useful information. Although there are still shortcomings in the process of using sensors, complementing multiple pieces of information can also improve the accuracy of image analysis. Nowadays, more and more scholars are investing in multi-source remote sensing image processing (Odum 1957; Pearson 1965).

The various information obtained at the same time is processed and analyzed to obtain a more comprehensive description of the specific scene. This method is called multi-source remote sensing image fusion (Pearson and Hanshaw 1970). After the images are fused, the accuracy of the information is greatly improved, the problems in the sensor are solved, and it is a more true response to physical phenomena (Qi et al. 2018; Ravikumar and Somashekar 2011). A long time ago, foreign countries began to study the content of multi-source remote sensing image fusion, but it was not until 1979 that the study of remote sensing image fusion was on the right track (Sabria et al. 2019).

Combining the data obtained by using different remote sensors at the same time can make up for the shortcomings in the single remote sensing image information and make the image processing more accurate. Many experts at home and
abroad have invested in this area of research (Song et al. 2013). To sum up, it can be seen that the research work of multi-source remote sensing image processing has already yielded initial results, whether at home or abroad (Tamers 1975; Tan et al. 2012). Combining information from multiple information sources can make up for the shortcomings of single information, make the effect more complete, and make the researchers’ translation of images more accurate. This conclusion has been proved by a large number of experimental results. However, most of the current researches start with the classification of remote sensing images or the translation of images on a macro scale. After the resolution of remote sensing data continues to increase, people can obtain more detailed information about the image through various channels (Tan et al. 2014). Therefore, in the future work, it is necessary to increase the research on the translation of small target images (Tong and Zhang 1989).

When designing traditional residential buildings, many factors, such as environmental images, technical experience, and artistic techniques, are often displayed (Truesdell and Fournier 1977).

1. Space combination

When making space combinations, pay attention to the local spatial layout habits. The distance between each floor of residential buildings is clearly defined. There will be differences in height among the building groups, and the later buildings will be significantly higher than the previous ones (Truesdell and Hulston 2017).

2. Public space

When directly using public space, we must consider the publicity and tolerance of public space. The traditional living habit is that many people live in the same yard, and one family is very close together. There will be a laneway in the middle of each house. The formation of the laneway is not deliberately done by the designer (Van Stempvoort and Krouse 1994). This kind of naturally formed laneway will make people feel more cordial and at the same time avoid the problem of too rigid connections between private spaces and laneways (Vonsée et al. 2019).

3. Space fun

Traditional residential buildings do not take into account the regularity of the building when designing them. Therefore, the order of the buildings will form a natural form inadvertently. The free combination of architecture will not only bring people a cordial feeling, but also increase interest (Wang et al. 2000). Finally, in the architectural design, it is necessary to save land resources. The density of traditional residential buildings is low during construction, so a lot of land resources are wasted. Therefore, this aspect should be taken into consideration when designing buildings (Wang et al. 2007).

Materials and methods

Overview and research methods of coastal atmospheric climate research based on multi-source remote sensing images

Overview of the study area

The sediment on the seabed will move with the tide. According to actual tests, the surface sediment content in the study area is relatively small, less than 125 mg/L as a whole, and the average sediment content is not higher than 40 mg/L. Clay silt and fine silt are the most in sediments in the sea. The sediments from land to ocean are not the same, and there are certain laws in these changes. The sediments close to the land are the thickest. The diameter of the surface sediments is between 0.004 and 5 mm, and the silt is the most widely distributed in all sediments (Wang et al. 2009).

Data source

The distribution of monitoring points in the study is shown in Fig. 1.

In all the research data, there are a total of 52 sets of field data, of which the remote sensing image data comes from the nearshore data obtained on September 20, 2020. The water quality sample data used in the experiment comes from different depths of the water body and has been filtered (Wei et al. 2018).

Atmospheric correction based on 6S model

The 6S model is developed on the basis of the 5S model. This model takes into account that the surface of the earth is not a uniform Lambertian surface and eliminates environmental reflection problems by correcting the proximity effect between the target and the background (Zhao et al. 2011). The model uses state approximation and successive scattering algorithms to calculate scattering and absorption, which improves the parameter input of the model (Zhao et al. 2018). The correction principle of the 6S model is as follows:

For a non-uniform target with a reflectivity of $R$, the atmospheric reflectivity received by the sensor is as follows:
The FLAASH atmospheric correction model is more suitable for hyperspectral and multispectral remote sensing data. This atmospheric correction method can generate classification maps, which can not only eliminate noise but also smooth the spectrum (Zhou et al. 2008). However, the premise of using this model is that the ground surface is a standard flat Lambertian, and the pixel radiance obtained by the sensor is as follows:

\[ L = \left( \frac{A}{1 - \rho_S} \right) + \left( \frac{B \rho}{1 - \rho_S} \right) + L \]  

\[ R^*(\theta_x, \theta_y, \phi_v) = T_H(\theta_x, \theta_y) \left\{ R_a(\theta_x, \theta_y, \phi_v) + T(\theta_x) \left[ R_c e^{\frac{\pi}{4}} + R_P T_a(\theta_x) \right] \right\} + \theta \]

**Atmospheric correction based on FLAASH model**

The FLAASH atmospheric correction model is more suitable for hyperspectral and multispectral remote sensing data. This atmospheric correction method can generate classification maps, which can not only eliminate noise but also smooth the spectrum (Zhou et al. 2008). However, the premise of using this model is that the ground surface is a standard flat Lambertian, and the pixel radiance obtained by the sensor is as follows:

**Image quality evaluation**

The two most important parts when evaluating image quality are the average gradient and the information. The speed of change is obtained by analyzing the small differences in the image (Zsolt et al. 2002). The larger the value, the clearer the image. In addition, it can also judge the amount of information carried in the image. The larger the amount of information, the more it can make up for the lack of single information. The average gradient and the information direct calculation formula are as follows:

\[ AG = \frac{1}{(m-1)(n-1)} \sum_{x=1}^{n-1} \sum_{y=1}^{m-1} \left\{ \left( \frac{\Delta f(x,y)}{\Delta x} \right)^2 + \left( \frac{\Delta f(x,y)}{\Delta y} \right)^2 \right\} / 2 \]  

\[ H = -\sum_{i=0}^{\max} P_i I_b P_i \]  

**Evaluation of the effect of ground target information correction**

When evaluating the effects of two atmospheric corrections, NDWI was selected, and the data obtained by using different algorithms were compared and analyzed, and the same index data, such as the root mean square error, should be used when calculating with the algorithm. The data can be used by IA. The smaller the IA, the greater the difference between the conclusions drawn by the two methods. The calculation formula of the NDWI value is as follows:
Multi-source remote sensing image feature point matching technology and its experimental research

Multi-source remote sensing image feature point matching technology

In order to solve the problem of feature point matching, the author improved the algorithm of feature point matching and proposed a new technology that can perform feature point matching of multi-source remote sensing images. First, in order to make the gray value of the matched image show a linear change trend, the spectral information of the multi-source remote sensing image should be fitted, and then when the feature point is matched, an improved algorithm should be used. Finally, in order to remove the wrong matching points, a random sampling consensus algorithm is used. The detailed process is shown in Fig. 2.

Analysis of spectral characteristics of multi-spectral images If two objects are in the same frequency range and have the same spectral characteristics at the same time, these characteristics will not change during imaging. Therefore, it can be considered that if the imaging conditions are the same and the frequencies of the multi-source remote sensing images are the same, then the gray scale will change linearly. When other imaging conditions are the same, if the intensity of light emitted by people is different, the reflectance obtained is still the same.

Multi-spectral image band fitting Based on the above analysis, it can be concluded that if the imaging conditions are the same, and the two remote sensing images are in the same frequency range, then the change in the gray value of the corresponding pixel in the corresponding band is linear, and the characteristics obtained in this way are better. Generally, the probability of two remote sensing images in the same frequency range is relatively small. In order to obtain two images in the same frequency range, the bands and multispectral bands of the two remote sensing images waiting to be matched can be fitted. Most satellites have panchromatic and multispectral sensors, so the fitting is better. In theory, multiple spectral bands can be split to obtain panchromatic bands of the same spectral range. If the radiant energy of each segment is added up, the radiant energy of the panchromatic band can be obtained.

Image feature point extraction after band fitting

Although the fitting process has been carried out, there is still a difference in gray value compared with the true linear change. If the scale is enlarged, the difference in gray value can be

NDWI = \frac{\rho_{\text{green}} - \rho_{\text{air}}}{\rho_{\text{green}} + \rho_{\text{air}}} \quad (5)

Fig. 2 Flow chart of multi-source remote sensing image matching. a Before calibration. b 6S model after correction. c Corrected FLAASH model

Fig. 3 Image comparison of the two methods before and after atmospheric correction. a Green light band. b Near-infrared bands
reduced, so pay attention to increasing the scale when establishing the scale space. There may be matching errors when matching feature points, which can be divided into two types: (1) when the scales are different, the feature point matching errors are prone to occur. In order to avoid this situation, when the two remote sensing images are the same, it should be possible to detect the feature points with the same position in the same group in the same scale space in the normal state. Therefore, when performing feature point matching, the scale limit should be selected according to the ratio of the remote sensing image resolution; (2) when the position has no correspondence, there are points that are close to the matching point. In order to reduce the occurrence of matching errors, researchers usually increase the threshold for such problems. In this study, the author set the ratio threshold to 2.25.

Although corresponding measures have been taken in order to avoid the occurrence of errors, false matching will still occur. In this article, the author uses random sampling to remove false matching points.

Results

Image quality evaluation after atmospheric correction

Figure 3 shows the composite image before atmospheric correction and after atmospheric correction using two models.

According to Fig. 3, the visual effect of the image is better after atmospheric correction. Although both atmospheric correction methods can enhance the contrast of the image and make the visual effect of the image better, the image effect after the 6S model correction is better.

Figure 4 is a comparison chart of the reflectivity of the image in Fig. 3 between the green light band and the near-infrared wave band.

According to Fig. 4, the reflectance of the image is significantly reduced after correction, and the reduction of the reflectance value after FLAASH correction in the two models is relatively small, which to a certain extent shows that the effects of the two atmospheric correction models compared are relatively good, it can weaken the radiant energy of the atmosphere, but compared with the FLAASH model, the 6S model has a better atmospheric correction effect.

From Fig. 4, the reflectance information of images with different center wavelengths can be obtained, and the specific reflectance results are shown in Table 1.

According to the data in Table 1, the two models improve the quality of the image. Before the atmospheric correction, the reflectivity of the image affected by the atmosphere is higher than the original reflectivity, which is not the true reflectivity. In the blue band, the reflectivity changes before and after atmospheric correction are relatively large, because the effect of Rayleigh scattering
in the atmosphere is relatively strong. After the correction, the reflectivity range of each band has also increased, which shows that after the correction, the image is clearer and the contrast is also improved. After comparing the data of the two models, it can be seen that the effect of the 6S model is better.

In order to better evaluate the image quality after atmospheric correction, the author calculated the relevant evaluation indicators, as shown in Table 2.

According to the data in Table 2, the average gradient is relatively increased after atmospheric correction, which indicates that the image is clearer after correction, the quality is improved, the contrast is also improved, and the information after 6S correction is higher than the FLAASH model. The reflection characteristics of different ground objects are different, but the atmosphere blurs the characteristic information during the transmission process, so atmospheric correction and information entropy must be carried out. After the 6S model is corrected, the characteristics of the image are more obvious.

### Evaluation of the correction effect of ground target information

The measured spectrum is compared with the image after atmospheric correction. The specific calculation results are shown in Table 2.

Figure 5 is a comparison diagram of field measurements under the two models.

Comparing the data shows that, compared with other models, the 6S model is more suitable for atmospheric correction of multi-spectral images of marine waters.

| MODIS image       | Evaluation index |       |       |
|-------------------|------------------|-------|-------|
|                   | Average gradient | Information entropy |
| Original image    | 2.197            | 7.101 |
| FLAASH corrected image | 2.598 | 7.672 |
| 6S correction image | 3.052           | 7.310 |

### Test experiment

In the test experiment, all the feature points are matched and the detection effect is compared.

### Panchromatic and multi-spectral band feature point matching

In remote sensing applications, it is necessary to compare different bands, and fitting is usually used in the matching process. Because the size of the band is the same, it is necessary to match the fitted feature points with the real feature points. Since there is a linear transformation between the fitted and actual corresponding values, the matching effect obtained is better, and the specific matching effect is shown in Fig. 6.

According to Table 4, it can be seen that the method proposed by the author in this article is obviously better than other methods.

### Multi-spectral and multi-spectral image feature point matching

Use CBERS-02B satellite and HJ-1B satellite multi-spectral images for testing.

1. **Fitting image**

Four bands are selected for linear fitting, and the same wavelength is put into the expression obtained by linear fitting, and then two single-band remote sensing images of the same wavelength are obtained.

2. **Feature point matching**

Select the feature points of any band of the two images to match (table 5).

The matching effect of different algorithms is shown in Fig. 7. According to the figure, it can be seen that the algorithm used by the author in this article is obviously better than other algorithms.

### Remote sensing inversion of suspended sediment concentration in coastal areas

Select and process remote sensing images near the coast, carry out inversion research on the basis of 6S model atmospheric correction, and obtain images after water and land separation.

The remote sensing inversion model of suspended sediment concentration is established through data analysis, the remote sensing image is inverted, and the result is represented by a sediment distribution map, as shown in Fig. 8.
During the research process, the author selected 10 inspection points and evenly distributed them on the profile. In order to judge the accuracy of the model, the measured and inverted values of sediment were compared. Figure 9 is a scatter diagram drawn based on the measured and inverted values of the sediment concentration at the detection point, and the correlation coefficient is 0.977.

The specific measured values and inversion results of the detection points are shown in Table 6. The average absolute error of the model is 2.673 mg/L, the average relative error is 4.165%, and the root mean square error is 4.29 mg/L.

Discussion

Research on traditional residential space design

At the current stage, when designing traditional houses, designers usually pay more attention to the sense of experience, which can affect the cultural characteristics of the houses. The use of characteristic resources of traditional culture is not only conducive to improving the promotion of traditional culture, but also conducive to the realization of economic benefits. In this article, in order to analyze the experience design in the design of traditional residential space, the author analyzes the key points of the experience design of traditional residential buildings in a certain area of Sichuan, analyzes the visual experience, and discusses the advantages of experiential design and the economic benefits brought.

Visual experience analysis

In order to satisfy the occupants’ visual experience, designers will take the space design elements of traditional houses into consideration when designing the street space. In order to fully design the boundary contours along the street, designers often take the lead in considering the street space. When designing, they often pay more attention to the integration of local characteristic elements. In the design, the house will be designed according to the architectural characteristics of the time and
the purpose of the house. If the house needs to be demolished or renovated, different gables should be used to cut the original building body, so that it can bring to the occupants a better experience, as shown in Fig. 10. When investigating the local houses, the researchers found that the local buildings are artistic, able to reproduce historical life scenes, and create a historical atmosphere for the residents. When people walk on the streets, they seem to have traveled to the time. In order to protect traditional resources, the original local historical buildings should be protected in space design so that consumers can have a better visual experience. For example, the local area will retain blacksmith shops and some religious buildings to create historical scenes and religious atmosphere. The existence of Yamen and ancient piers will make people feel a strong historical atmosphere.

Behavioral experiential analysis

When designing a building, designers should pay attention to the sense of behavioral experience, comprehensively consider the location, purpose, and characteristics of the building to design the building, so that consumers can have a better perception of the space. When designing the space of traditional houses, it is necessary to consider the construction of different functional areas to provide consumers with better leisure places. Starting from the traditional dwelling space, the design of life experience should be carried out. In order to allow consumers to experience the real residential life, it is necessary to combine different leisure content, such as accommodation, trading, catering, and so on. When a designer designs a commercial building, he can design the building with a front store and a rear residence according to ancient architectural methods. The store money is used for trading goods, and the store is used for residence. In addition, the area of traditional buildings in some old neighborhoods in the local area is very small and has at least two functions, as shown in Fig. 11.

The local architectural design perfectly blends the local characteristic culture. There is such a tradition in the local area. People watch dramas, listen to storytelling, and convey information through teahouses. Therefore, there are teahouses everywhere in the local area. The local tea culture has promoted the local economic development. People exchange information in teahouses, watch entertaining programs, and make people feel relaxed while meeting their spiritual and cultural needs. Generally, when a teahouse is to be built, the location of the teahouse is usually placed on the bank of the river, and multiple teahouses are built side by side in a linear manner. When the teahouse interior is arranged, in order to maximize the advantages of the landscape, the location of the tea table is also extending from the inside to the outside, this design can give consumers a better feeling.

Analysis of economic benefits

In order to stimulate local economic growth, the realization of local economic benefits must fully meet the needs of consumers and make consumers willing to consume for them. When designing a space, it is necessary to incorporate history and culture into the design. Designing a space is actually designing for life. When designing leisure and entertainment, it is necessary to combine all aspects of entertainment projects and put consumers’ feelings in the first place. When the needs of consumers are met, the local popularity will increase rapidly, and more tourists will come here, which will effectively promote the development of the local tourism industry. At the same time, it can also promote other subsidiary industries and

| Algorithm | PAN and MS | Number of matches | Number of correct matches | Correct rate |
|-----------|-----------|------------------|--------------------------|-------------|
| Algorithm | 239       | 239              | 100%                     |             |
| GOM-SIFT  | 99        | 90               | 90.90%                   |             |
| SR-SIFT   | 87        | 81               | 93.10%                   |             |
| SIFT      | 96        | 92               | 95.83%                   |             |

| Algorithm | CBERS-02B and HJ-1B | Number of matches | Number of correct matches | Correct rate |
|-----------|---------------------|------------------|--------------------------|-------------|
| Algorithm | 11                  | 11               | 100%                     |             |
| GOM-SIFT  | 5                   | 5                | 100%                     |             |
| SR-SIFT   | 5                   | 5                | 100%                     |             |
| SIFT      | 5                   | 5                | 100%                     |             |
Fig. 7  Schematic diagram of CI3ERS-02B and HJ-1B multi-spectral image matching

Fig. 8  The distribution of sediment concentration in the coastal waters. a SIFT feature point detection. b GOM-SIFT algorithm detection. c SR-SIFT feature point detection. d The algorithm proposed in this paper
help promote local economic growth. In areas with a relatively long history and culture, the traditional culture is integrated into the building during architectural design to create a historical atmosphere, which is conducive to local development, as shown in Fig. 12.

Research and thinking on the design intention of traditional residential space

In designing the history of traditional residential buildings, many factors are often displayed, such as environmental imagery, technical experience, and artistic techniques. First of all, pay attention to the local spatial layout habits when making space combinations. The distance between each floor of residential buildings is clearly defined. There will be differences in height among the buildings, and the later buildings will be significantly higher than the previous ones. Secondly, when directly using public space, we must consider the publicity and tolerance of public space. The traditional living habit is that many people live in a yard, and one family is very close together. Every time there is a laneway in the middle of the house, the formation of the laneway is not deliberately done.

| Table 6 | Statistic results of measured and inverted sediment concentration at inspection points |
|---------|-------------------------------------------------------------------------------------|
| SSC     | Measured value (mg/l) | Inversion value (mg/l) | Relative error (mg/l) | Absolute error (mg/l) | Root mean square error (mg/l) |
| Minimum | 6.19                  | 9.37                  | 0.00                  | 3.18                  | 4.29                        |
| Max     | 67.3                  | 69.14                 | 4.39                  | 1.84                  |                             |
| Average value | 23.57            | 20.57                 | 3.94                  | 3.00                  |                             |
by the designer. This kind of naturally formed laneway will make people feel more cordial, and at the same time avoids the problem of too rigid connections between private spaces and laneways. Thirdly, to create interesting points, traditional residential buildings did not consider the regularity of the building when designing, therefore, the order of the buildings will form a natural form inadvertently. The free combination of architecture will not only bring people a cordial feeling but also add interest. Finally, land resources should be saved during architectural design. Traditional residential buildings have low density during construction, so a lot of land resources are wasted. Therefore, this aspect should be taken into consideration when designing buildings.

Unlike modern buildings, traditional houses have their own characteristics. No two buildings are exactly the same, but they contain the same space spirit and can convey a consistent national culture. This construction method is different from the wooden frame structure of Japanese residents, and it is also different from the masonry system of Western Europe. In the research on the spatial characteristics of traditional Chinese residents, the author believes that the reason for the unification of the styles and features of many residential buildings is that the designers pay more attention to the axis and repetition when constructing the traditional residential buildings. Repetition is the repeated use of a layout method. Although the repeated design method will make the construction of the town more unified, it also reduces the interest. Not all traditional buildings use the two methods of repetition and axis during construction. Some areas still retain the local architectural style and characteristics during construction. With the development of the times, people are increasingly pursuing uniqueness. Whether the traditional residential space composition characteristics should continue to be used is a question worthy of discussion. The new era should also have the characteristics of the new era, otherwise the newly built towns and lanes will still be expressive and will not be loved by people.

Conclusion

With the advancement of technology, people can get higher resolution remote sensing images. With the increase in demand, more and more researchers are engaged in the interpretation of remote sensing images. In the process of image interpretation, the characteristics of images have a wide range of applications. Nowadays, people’s data acquisition technology is more and more advanced, and a large amount of remote sensing data can be acquired every day. How to process these data more intelligently is a hot spot of current research. In response to this problem, in this article, the author studied the dynamic target characteristics of multi-source remote sensing images. When the characteristics of the target are more common, the researcher does not consider the resolution of the image, but only pays attention to the target characteristics of the image, so the results obtained are not accurate and scientific. In the process of researching multi-dimensional target feature vectors, the author consulted a large number of literatures. Through the literature, we know that electromagnetic scattering can better describe the image, which can make the description of the image more accurate. The rapid development of multi-source remote sensing technology has prompted a large number of scholars to invest in remote

Fig. 10 Visual experience design of traditional houses

Fig. 11 Experience design of traditional residential space

Fig. 12 Analysis of economic benefits of traditional residential design
sensing image atmospheric correction methods. When the sensor receives the reflected information, it will be affected by the atmosphere, so the reflectance obtained is inaccurate, and the radiation of the atmosphere greatly reduces the contrast of the image, leading to the generation of radiation errors. Even if the data obtained in this way has undergone a lot of processing nor can it improve accuracy. The gray value of multi-source remote sensing images does not change linearly, so there will be mismatches when matching feature points. In order to solve the problem of mismatching, spectral information is used when matching feature points, which can reduce the gray effect of the non-linearity of the degree value when the feature points are to be matched, has improved the accuracy to a large extent. When designing traditional houses, we should pay attention to the consumer’s sense of experience and integrate traditional house resources into the design, so that traditional house resources can give full play to their functions, while meeting consumer needs, expanding influence, and opening up visibility. More consumers are willing to come here, which is conducive to promoting the development of the local tourism industry. At the same time, it can also promote the progress of the tertiary industry and bring economic benefits to the local area. Experiential design is a new design idea, which can restore the historical style to the greatest extent, bring a better sense of experience to residents while satisfying comfort, and help improve the quality of life.

Declarations

Conflict of interest The authors declare that there are no competing interests.

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