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Information Theory Basis of Multi-band Satellite Remote Sensing Image

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Abstract: This paper discuss multi-band satellite digital image synthesis and information volume. The multi-band digital image color synthesis, multi-spectral image band combination and multi-band digital image information volume formula are introduced and discussed in detail. Some examples are given to verify the principles of image synthesis.

1 Introduction

The essence of satellite remote sensing is to sample and encode remote sensing targets to achieve remote information acquisition, while remote sensing image interpretation is to decode and restore the acquired information, and ultimately achieve target recognition and analysis. This process from the goal to the goal constitutes an information transmission link, which can be studied with the help of information theory and methods to provide scientific guidance for us to better analyze and interpret our needs, restore remote sensing information, and interpret remote sensing targets. Therefore, this chapter focuses on using the basic knowledge of information theory, establishing a general model of satellite remote sensing information theory, focusing on optical remote sensing to study the information measurement theory of satellite remote sensing images, and discussing related information theory methods of satellite remote sensing image interpretation in combination with practical applications.

2 Multi-band digital image color synthesis

For satellite remote sensing digital images, what the satellite records and transmits to the ground station is a matrix composed of numbers, which cannot be recognized and perceived by human eyes. The process of artificial interpretation of satellite images can be interpreted as the process of human eyes perceiving digital images and analyzing them to extract information. The image can only interpret the required information through the display process. Therefore, we need to understand the basic image processing methods such as display process, image stretching, etc.

Satellite digital image display is the process of converting a series of discrete digital matrices into images visible to the human eye. And the pixel itself has no color, how to convert the pixel value recorded by the sensor into a color display effect.

The process is illustrated in Fig.1 as follows:

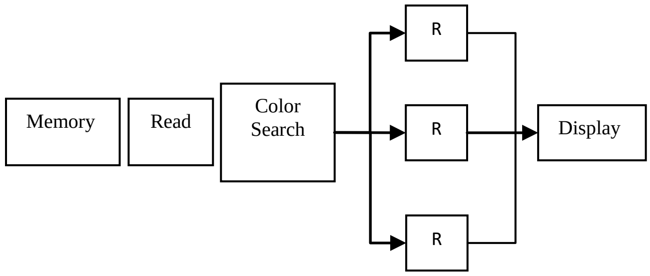

Figure.1 Image color synthesis

From this process, it can be seen that the process of remote sensing image display is the process of using the selected band of remote sensing data as R, G, and B channels and giving different colors. If R, G, and B are all assigned by one band, then the final display is a single-band black and white image, otherwise it is displayed as a color image. A very important step in color display is to assign the value represented by each pixel to the corresponding color. At this time, the collection of the most basic sources of color is called the color model, and the commonly used color models are: RGB, HIS, etc.

The above figure reflects the human eye's ability to perceive visible light in different wavelength ranges. The figure shows that the human eye's perception of light is between 400nm and 700nm. In other words, the human eye can perceive colors only when the spectral information is within this range. The difference between color and achromatic color is that achromatic color refers specifically to grayscale, and color refers to various colors other than the black and white series.

The display of color images is realized by color synthesis. The main methods of color synthesis are: Pseudo-color synthesis, true color synthesis, false color synthesis, etc.

1) Pseudo-color synthesis

Pseudo-color synthesis is the process of converting a gray-scale image into a color image. The main synthesis method is density segmentation. Density segmentation is to segment the single-band remote sensing image gray range, and assign a different color to each segment. The purpose of this is to improve the difference of image display, which is more conducive to the interpretation of the target. Because pseudo-color synthesis uses a single band as the rgb channel, and the color of the image usually does not match the actual features, it is called pseudo-color.

2) True color synthesis

True color synthesis is to select the red band, green band, and blue band as RGB for synthesis when the three-channel band is selected. At this time, the synthesized color is closest to the actual color of the object, so it is called true color synthesis.

3) False color synthesis

False color synthesis is when performing rgb three-channel band selection, the way of band selection is arbitrary. The purpose of this is to use different band combinations to make the final displayed image more in line with the human eye's visual cognition ability, which is more conducive to highlighting the target category.

3 Multi-spectral image band combination

In common digital camera photography, the camera sensor can only capture the energy of the three bands of red, green and blue. Therefore, ordinary digital cameras capture true color composite images. However, in aerospace remote sensors, the number of bands that the sensor can capture energy is generally greater than three.

In multispectral remote sensing, the false color composite image can use different band combinations, so the ability to express the richness of the feature information is different. In theory, we can use different band combinations to highlight the goal of interpretation, thereby reducing the difficulty of visual interpretation and increasing the speed of interpretation. Among them, the band combination that is most conducive to interpretation is called the best band combination. Let's take Landsat8 as an example to introduce the effect of image synthesis under various band combinations, and use the OIF index to evaluate the amount of information that can be extracted by band synthesis.

Landsat 8 is the eighth satellite launched by the US Landsat series. It was successfully launched on an Atlas-V rocket at Vandenberg Air Force Base in California in 2013. The sensors carried by the Landsat8 satellite mainly include OLI (Operational Land Imager) sensors for multi-band imaging and TIRS (Thermal Infrared Sensor) sensors for thermal infrared imaging. The information of each band is as follows:

Table 1 LandSat8 sensor data

sensor type	Wave Band	Wavelength range (μm)	Spatial resolution (m)
Operational Land Imager	Band 1 Costal	0.433~0.453	30
	Band 2 Blue	0.450~0.515	30
	Band 3 Green	0.525~0.600	30
	Band 4 Red	0.630~0.680	30
	Band 5 NIR	0.845~0.885	30
	Band 6 SWIR 1	1.560~1.660	30
	Band 7 SWIR 2	2.100~2.300	30
	Band 8 Pan	0.500~0.680	15
	Band 9 Cirrus	1.360~1.390	30
Thermal Infrared Sensor	Band 10 TIRS1	10.60~11.19	100
	Band 11 TIRS2	11.50~12.51	100

1) The combination of 4, 3, and 2 bands is a true color synthesis, which is mainly used to reflect the color of actual features.

Figure.2 4, 3, 2 band synthesis

2) 7, 6, 4 false color synthesis. This synthesis method uses short-wave infrared bands, so it has a good effect on the detection of cities or residential areas. The residential areas are given purple in the following figure, so the urban targets are highlighted display.

Figure.3 7, 6, 4 band synthesis

3) 5, 6, 4 false color synthesis, because the 6 band can make soil and water display higher contrast, so this color synthesis method can effectively distinguish land and water. The river in the mountains as shown below can be displayed more clearly than true color synthesis.

Figure.4 5, 6, 4 band synthesis

4) The false color synthesis of 6, 5 and 2 is used for crop monitoring, which can effectively interpret the cultivated land in mountainous areas.

Figure.5 6, 5, 2 band synthesis

5) The false color synthesis of 5, 4, and 3 can highlight the vegetation, where the vegetation is given a dark red color, as shown in the figure below.

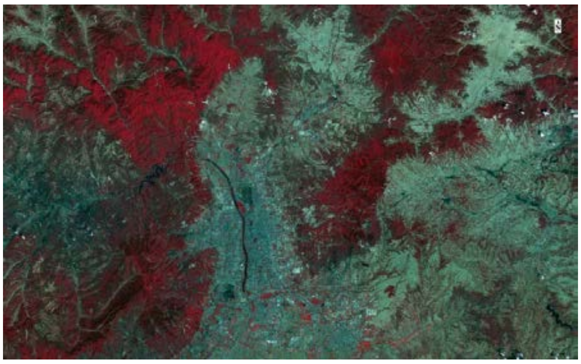

Figure.6 5, 4, 3 band synthesis

4 Multi-band digital image information volume formula

Multi-band digital images are the result of multi-band combination, and different band combinations will affect the amount of information in the entire image. It has been proved that there is a certain correlation between the bands of the image, and the natural true color band synthesis method 4-Red, 3-Green, and 2-Blue in landsat8 is taken as an example. Assuming that the single-band information of bands 4, 3, and 2 are W_4, W_3, W_2 respectively, the total information of the combined image is:

$$W_{4,3,2} = W_4 + W_3(1-\rho_{4,3}) + W_2(1-\rho_{4,2})(1-\rho_{3,2}) \quad (1)$$

In the formula, $\rho_{x,y}$represents the correlation coefficient between the x and y bands. For other band combinations and the number of bands is different, the amount of multi-band digital image information can be deduced by analogy. The following figure shows the covariance and correlation coefficient of each band of an image of Landsat8 obtained in ENVI.

After understanding the calculation process of digital image information, we take the 4, 3, and 2 band combination of landsat8 image as an example to introduce the process of obtaining the information of an image as follows:

① Calculate image information entropy;
② Calculate noise channel equivocation;
③Calculate the correlation coefficient of neighboring elements;
④Find the band variance and correlation coefficient matrix;
⑤ Substitute the information volume formula to solve.

5 Conclusion

The process of artificial interpretation of satellite images can be interpreted as the process of human eyes perceiving digital images and analyzing them to extract information. The image can only interpret the required information through the display process. In this paper, the multi-band digital image color synthesis, multi-spectral image band combination and multi-band digital image information volume formula are introduced and discussed. Some examples are given to verify the principles of image synthesis.

References

[1] Hartley R V L.Transmission of information[J].The Bell System Technical Journal,1928,7(3):535-563.

[2] Shannon C E.A Mathematical Theory of Communication[J].The Bell System Technical Journal,1948,27(4):623-656.

[3] Shannon C E.Communication Theory of Secrecy Systems[J].Bell System Technical Journal,1949,28(4):656-715.

[4] Zhong Yixin. "Principles of Information Science" [M]. Beijing University of Posts and Telecommunications Press, 2002.

[5] Feng Zhiwei. 70 Years of Research on Computational Language in my country [J]. Language and Literature, 2019(4): 19-29.

[6] Xuehong Cao, Zongcheng Zhang. "Information Theory and Coding"[M]. Tsinghua University Press, 2018.

[7] Xu Hongtao. Research on the Information Amount and Uncertainty of Remote Sensing Images. Proceedings of the 2017 Annual Conference of Yunnan Society of Surveying and Mapping.

[8] He Shaoshuai, Yang Minhua, Li Weijian. Discussion on the source of fuzzy uncertainty of remote sensing data and its processing methods. Science of Surveying and Mapping.

[9] Gu Xingfa, Yu Tao. "Application-Oriented Space Remote Sensing Scientific Demonstration Theory Method and Technology". Science Press.

[10] Lin Zongjian, Zhang Yonghong. The amount of information and uncertainty of remote sensing and geographic information system data[J]. Journal of Wuhan University (Information Science Edition), 2006(07):569-572.

[11] Janes E T.Probability Theory:the Logic if Science[M].Cambrdge:Cambrdge University Press,2003.