The Use of Dual-Threshold Extraction of Waters Based on LIDAR Data

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Abstract: It is a difficult task for shadow and feculent water area processing when extracting water body from remote sensing image by traditional methods. Light Laser Detection and Ranging (LiDAR) is robust to gain point cloudy data from shadow and feculent water as it has less affection from that area. However, the point cloudy data is always with low resolution which results to contour line with low accuracy. A new approach called dual-threshold for water body extraction is proposed to improve the accuracy. Experiments results indicate the contour lines obtained through this way are accuracy and with details. The accuracy of water body extraction can reach 98.6%.

Keywords: lidar; water bodies; dual-threshold

1 Introduction

In the past 30 years, rapid and accurate information extraction of water images from the satellite remote sensing has become the main method in the area of the investigation of water resources, water resources, monitoring and wetland conservation. Domestic and foreign scholars have conducted extensive research, put forward and applied remote sensing images from a variety of methods to extract water bodies, such as: threshold value method, the difference method, ratio method, density segmentation, color discrimination, the rate calculation method, the spectral relationship analysis method, automatic knowledge-based method, shape-based water bodies recognition and classification methods and so on (Baltsavias 1999; Wu, de Leeuw et al. 2009). However, there are still some limitations, such as: the requirements for the spectral information are relatively high; most of the means spectra have relatively good results for the near-infrared or infrared remote sensing images. For the water bodies in the shadows, especially water in the shadow of mountain can hardly be extracted. In conclusion, the Original remote sensing data is good for the clear bodies of water but for the turbid waters, and effectively for large area of water bodies, but small water bodies.

Light Laser Detection and Ranging (LiDAR), including global positioning system (GPS), inertial navigation system (INS) and Laser Scanner, not only fast access to a range of surface high-precision three-dimensional point coordinates(Baltsavias 1999; Wehr and Lohr 1999), but also recording the echo intensity of laser and other information. Airborne laser radar system is an active remote sensing sensor. Theoretically, it can work in daytime or night, and little impact of weather conditions. As for the laser pulses, better than the traditional Photogrammetric methods, can partially penetrate the wood block and reach the real ground directly to get high-precision three-dimensional topographical information, it can be superiority aroused interest in surveying and mapping community. Brzank etl directly use LiDAR point elevation, two-dimensional point density and the echo intensity as the characteristic value, using supervised classification method extract water bodies and wetlands. Dalponte M (Dalponte, Bruzzone et al. 2008). and Mundt JT (Mundt, Streutker et al. 2006) fuse high-spectral imagery and LiDAR point cloud data to extracted features, and then classify the objects on the ground. This approach not only need the multi-spectral data which takes three-band RGB color and is received CCD camera integrated with LiDAR devices; the other hand, supervised classification and support vector machine method are used and all the methods need to manually select the samples.

Currently, in the airborne LiDAR data, point spacing is typically 10cml. Using single threshold value method to extract water body is not fine enough. Therefore, a dual-threshold method is proposed get a more accurate water body extraction result.

2 Water Body Extraction Using Lidar Data

Depths, pollution levels and lighting conditions of the waters led to a great deal of difference presentations in color images, and the building or a block cloud make the remote sensors device will not be able to obtain the true ground scene correctly, so using a color images to extracting water can be a great difficulties. But all the factors above are too trivial or insignificant to mention for the LiDAR data, what's more, the LiDAR point cloud data in water area has three distinct characteristics: (1) Laser-point sparse; (2) point cloud of the similar height; (3) weak echo intensity (H fle and Pfeifer 2007; Song, Han et al. 2002). Laser pulses can be easily absorbed by water, especially in clear water but; in turbid water although some laser reflection back. In a small-scale level,

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the data in the water area has very close height values. Laser intense reflected back from water surface is weak, which is called low- echo -intensity. As for the LiDAR point cloud data with these three perfect features, make it easier and more robust than the color images to extract the water bodies. Use of these three features, presents a direct water extraction based on LiDAR point, including the following specific steps: (1)To grid the DEM point cloud data; (2)The Grid feature clustering analysis;(3) the use of LOG operator extract fine edges of water bodies (4) the use of large threshold to obtain a reliable bodies of water (5) The combination of the two results to obtain accurate and reliable body of water.

2.1 The Point Cloud Data Grid

The original discrete airborne LiDAR point cloud data is irregular and need to be organized in order to quickly index the data within the specified range. The gridding method of the data is an efficient data management. In data processing, often each Grid can be seen as a processing unit Therefore, setting a reasonable size of the grid will play an important role in recognizing and t processing speed. If the grid size is too big, It can make a non-water body to be included in the same grid, which leads to inefficiency in locating the water. If the grid is too small, it is easy to extract empty area between the point clouds, resulting in the non-water areas is classified as water bodies and the instability of the water surface. For the processing efficiency, the larger grid, the less total number of blocks, and the fewer the number of processing units. Through the following methods to calculate the grid spacing a: n is the average number of points in one grid, σ is average density of point cloud, then, where σ = Total Points / Total area. Calculate the point number, mean elevation and elevation variance, in order to determine the parameters for the grid block to extract water bodies.

2.2 Classify the Water Grid

The point cloud data in the water area shows three obvious characteristics. These three characteristics manifested through the following ways: (1) When the points less than the threshold value, said point cloud scarce; (2) When the height variance is less than the threshold value, the points in the local area have similar height values; (3) When The surface of the water points and the average echo intensity are corresponding less than the threshold value, the echo is weak. (1) may also occur in the building block, and therefore the (2)and (3)are also needed. If there is no point in the grid, we can interpolate the height value using the nearest neighborhood method. Paper first find the focal point of the block k-nearest neighbor points, and then find some the lowest points of k-nearest neighbor, then get the average height value of the lowest n points, which is called the grid height. Many grids have the similar grid height. These places may be under water at the echo intensity of the characteristics of weak excluded. The same case occurred in these objects, such as plat rooms, ball ground, waters, roads and so on. Then you can use intensity and echoes to exclude all the objects but waters .Thus, by combining these three features, you can block by block to determine whether it is a water body.

2.3 Log Operator Extracting the Edge of Water Bodies

The edge pixels have smaller gradient value. In theory, Laplace edge detection operator can used to detect the edge pixels when the location of zero-crossing corresponding to the pixel. Thus, the pixels, which satisfy the threshold value, can be connected to get edges in the image. If the area where slope change is very slow, the edge gradient image often contains a large number of second-order gradient which are equal to zero. Thus, the gradient changes can be seen as a condition parameter for the edge detection. When the gradient change equals to zero, all edges will have been extracted, so the edge-line looks very complete. But many short-term edges result in the small changes in slope the generation, not a true break line. Break lines are generally longer and more obvious. Therefore, through the eight-neighborhood connectivity to strike a domain, remove those pixels of the small connected domains, and get a longer continuous edge.

2.4 Using Large Threshold to Get Reliable Edge-Line

With a larger gradient threshold, you can extract high credibility edge pixels. Break lines at most of the edge line has large gradient changes, and thus most of the pseudo-fault line of the edge will not appear. Using a large threshold value to extract edges, although the overall break lines of the edges can clearly be retained, but there is also part of the break lines at a smaller gradient, hence break lines at the edge line usually appear incomplete situation.

2.5 Combine Two Results to Obtain Precise Boundary

Combine the small gradient change results and the large gradients results to extract the complete and high confidence edge lines. When the ratio of the high edge pixels number and the small threshold value edge pixels exceeds a certain threshold, the lines can be seen as the edge of water body, then using the connectivity principle to connect the adjacent water body area together.

3 Data and Result

The data covers the Changyang city in Hubei Province of China, and was obtained in March 2008 with a flying height of 2200m. The point density is 1point /square meter, the results are shown in Figure 1, Figure 2, Figure 3:

Figure 1. A detailed results

Figure 2. A reliable results

Figure 3. The final result

4 Conclusions

AR data to extract the water body contour, we have used the dual-threshold method to get a precise outline of water body. Because of the three features of the water body using the LiDAR point data, and the shadows and turbidity make the ratio of miscarriage of justice very low. Firstly, using larger threshold to get rough outline of the water body, then using smaller threshold to get fine outline of the water body, in the end, combine the two results to get a better water body extraction result. This method can extract most of the waters, applicability, but there are some improvement, such as the cross section of the bridge will lead the water being cut off; for the narrow river, it is easy to break or get incomplete break lines; because of the buildings objects' obscure, there will be hollow space in the point cloud, and in this situation, using contextual information, it is easy to judge the object.

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