Accuracy in Remotely Sensed Urban Greenery Land Cover

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Abstract. The paper analyzed and compared the accuracy of urban greenery extraction from the different sensors images with different methods. It is necessary to compare the accuracy for the same area with different images, 30m TM image, 10m SPOT image and 2.44m QUICK BIRD image. Visual interpretation, classification based on the statistical and classification based on object are used to extract the urban Greenery from three kinds of sensors images with different resolution. Urban greenery extraction from high resolution image has higher accuracy using classification based on the object than that based on the statistical classified accuracy. The result shows that the sample and the statistical is the main factor to affect the accuracy by classification based on the statistical, while the segmentation scale is the main factor affect the accuracy by classification based on object.

Keywords: remote sensor image, image classification, greenery extraction, accuracy comparison.

1. Introduction

Urban greenery mainly contains gardens, parks, shade trees, greenery in inhabited area, Transportation greenery, beauty spot greenery, appropriative greenery and labor protection greenery, etc.

Urban greenery is able to protect and improve the city environment. Park system is the major part of urban greenery. Greenery has great benefit that can be neither displaced nor estimated.

It is necessary for the city greenery mapping and construction to extract high accuracy urban greenery information. In nowadays, more and more cities have applied remote sensing technology to the greenery statistics to improve its accuracy.

The same kind of objects generates different spectral attributes due to different resolution of sensors. Therefore, the spectral attributes of certain greenery should be concerned before the extraction of urban greenery information. The essence of urban greenery is vegetation. Diverse green plants have similar spectral attributes by reflection because of their photosynthesis. Within range of visible bands, the spectral attributes of healthy plants depend on their leaves because chlorophyll has a strong reflectivity on green band while has a strong absorption on blue and red bands. If the amount of chlorophyll declines due to the inhibition of a certain plant, the plant will turn yellow. Plants turn yellow or red when they are decrepit. The spectral attributes in near infrared bands depend on the structure of cells inside the leaves because the reflection comes from inner structure. Vegetation has a stronger disparity in near infrared bands than in visible bands. As a result, it is recommended to discriminate different plants by measuring the reflectivity confined in near infrared bands. In short wave infrared bands, the plants absorb or reflect the wave, seldom transmitting. The spectral attributes of plant are influenced by the amount of water it contains: the reflectivity of leaves is negative correlated to the amount of water. The amount of reflection is the function of the amount of water and the thickness of leaves. The spectral attributes of plants vary in different periods and states of health the same as spectral attributes of other objects which have timeliness and extensity.

The paper analyzed and compared the accuracy of urban greenery extraction from the different sensors images with different methods. It is necessary to compare the accuracy for the same area with different

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image, 30m TM image, 10m SPOT image and 2.44m QUICK BIRD image. Visual interpretation; classification based on the statistical and classification based on object are used to extract the urban Greenery from three kinds of sensors images with different resolution. Urban greenery extraction from high resolution image has higher accuracy using based on the object than based on the statistical classified accuracy. The result shows that the sample and the statistical is the main factor to affect the accuracy by classification based on the statistical, while the segmentation scale is the main factor affect the accuracy by classification based on object.

2. Methodology

In order to compare the Accuracy, Visual interpretation, classification based on the statistics and classification based on object are used to extract the urban greenery from three kinds of sensors images with different resolution.

Extracting greenery information could be summarized to two ways: interpretation by eyes and automated classification.

2.1. Visual interpretation

Traditionally, we send investigator to extract greenery information, this method is precise and reliable yet of low efficiency. Remote Sensing images provide the probability of extracting greenery information from global view. In medium resolution image, interpretation of greenery is mainly according to its spectral attributes.

With the emergence of high resolution image, it is possible to apply high resolution images to urban remote sensing. Extracting greenery from image becomes a significant field of application of urban remote sensing. Visual interpretation of high resolution remote sensing images could access tone, shape directly. Therefore, Visual interpretation could cognate the specific class of greenery besides judge whether an area is greenery. However, the difficulty of high resolution image is the extraction of boundaries of objects. Because of the abundance of details of objects in high resolution images, the feature values of objects are usually lack of statistical meaning which deduces the unacceptable results of automated classification. In short, the promotion of resolution increases the difficulty of extraction of information as well provides affluent information.

Visual interpretation has also high accuracy and reliable. Through visual interpretation, the samples can be provided to train computer and to identify categories of discriminant function.

2.2. Classification based on the statistics

Automated classification basically considers the clustering of classes in feature space. The traditional method based on statistics presumes object has a certain distribution in the feature space which has negative effects on the accuracy of classification.

In the feature space, the pixels that belong to one land-cover type will be accumulated in one cluster. Different land-cover types with distinct spectral pattern will form the pixel clusters that are separated properly in the feature space (as shown in figure 1 and figure 2) (Gao yuan, 2003).
There are three kinds of classification based on the statistics: Pipeline classifier, Minimum distance classifier, Maximum likelihood classifier.

Parallelepiped classifier uses spectral values in each class training set (Lillesand, 2001). This range may be defined by the highest and lowest digital number value in each band and appears as a rectangular area in two-channel scatter diagram. An unknown pixel is classified according to the class range. Parallelepiped classifier is very fast and efficient computationally (Lillesand, 2001), but low accuracy.

The mean spectral value in each band for each class is determined by visual interpretation. These spectral values comprise the mean vector for each class. A pixel of unknown identity may be classified by computing the distance between the value of the unknown pixel and each of the class means. If the pixel were further than an analyst defined distance (distance threshold) from any class mean, it would be classified as “unknown” (Lillesand, 2001). This distance threshold could vary for each class depending on the expected degree of compactness of that class. Compactness might be estimated from the standard deviation for each feature of the pixels making up the training sample for a given class (Mather, 1987).

The maximum likelihood classifier quantitatively evaluates both the variance and covariance of the class spectral response patterns when classifying an unknown pixel. An assumption needed in maximum likelihood classifier is the distribution of pixels forming the class training data is Gaussian (normally distributed) in the feature space. Under this assumption, the distribution of a class response pattern can be completely described by the mean vector and the covariance matrix. Given these parameters, the discriminant function is determined for each class, so the statistical probability of a given pixel value being a member of a particular land cover class may be computed. An undefined pixel is classified by computing the probability of the pixel value belonging to each class with discriminant function which is from training samples. After evaluating the probability in each class, the pixel would be assigned to the one with highest probability value or be labeled “unknown” if the probability values are all below a threshold set by the analyst (Lillesand, 2001).

Three classifiers are shown in figures 3, 4, 5.

2.3. Classification based on object

Objected-based information extraction surmounts the defects of traditional method. Besides making full use of spectral information, it also adopts the spatial information includes texture, shape and context. Object-based classification obtains the homogenous objects by multi-resolution segmentation in preprocessing step. Then, it chooses desirable features in the level of object to apply to fuzzy classification under the theory of fuzzy base. The essence of this algorithm are how to obtain the meaningful objects in the process of segmentation, which feature to choose and how to adjust the membership function that is applied to the chosen features.

Multi-resolution segmentation of remote sensing image minimizes the heterogeneity during the merging process. It is according to the conception that each area should have a minimized heterogeneity in given segmentation scale. The criterion of heterogeneity consists of two parts: the tone criteria and shape criteria. A Tone criterion is the segmentation of spectral heterogeneity while shape criterion is helpful to avoid the unexpected shatters. The process of segmentation begins at any pixel in the image. Then it merges such
pixels to small objects and continues merging the small objects to bigger ones. The segmentation loop will not end until achieve the limitation discussed above.

After the process of segmentation, the obtained objects have abundant features, which provide the possibility of classification. Different classes adopted different features and membership functions according to the specification. Therefore, the comprehension of interested objects including the spectral features, spatial features, texture features and relationship of objects is needed in advance. The extraction of information could be improved only if we master such features with a better understanding of the meaning of objects.

The adopted features and level varies from images from different sensors.

To TM images, the extraction of greenery adopted the mean spectral values, with applying the Nearest Neighbor algorithm which requires a number of samples.

To SPOT images, two levels is adopted with the first differentiate aquatic area and the opposite by using the mean value of the fourth band. The second is used to divide the non-aquatic area into vegetation and grass, using the mean of spectral values and the texture values.

To Quickbird images, three levels system is adopted, with the first differentiating the aquatic areas and the land areas, the second dividing land areas into greenery and non-greenery and the third dividing vegetation and grass.

The shadows in Quickbird images have to be taken into consideration. The vegetation and buildings produce shadows. The shadow of buildings is of mainly concern because the amount of vegetation and terrain shadow is finite and the NDVI could eliminate the vegetation and terrain shadow to some extent. The identification of shadow and non-shadow involves NDVI, mean of the fourth band value, and the ratio of mean of the first band value and the fourth band. The limitation of some classes could be obtained by statistical way, For example, the mean of spectral value.

3. Data and Result

3.1. Data
Three kinds of multi-spectral images including 30m TM image, 10m SPOT image and 2.44m QUICK BIRD image of Wuhan University acquired almost in the same time are used to compare the accuracy of urban greenery extraction (see fig. 6). There are rich greenery, both the mountain's natural vegetation and a large number of artificial planting vegetation, there is still a certain cultivation of artificial turf.

![TM image](image1) ![SPOT-5 image](image2) ![QUICK BIRD image](image3)

Fig.6 Study areas

3.2. Result
Visual interpretation result is given in Fig.7, Supervised classification result is given in Fig.8 and Classification result based on object is given Fig. 9.

The accuracy is shown in tables 1, 2, 3, 4. In generally, the extraction accuracy of Greenery is close from three kind images. It is more precise from the Quickbird image, while low accuracy from TM images mainly for grassland was divided into vegetation.
From the specific distribution, vegetation-extraction has good results from large areas vegetation than from dispersed vegetation.

Table 1 Accuracy of urban greenery extraction from TM images

<table>
<thead>
<tr>
<th>class</th>
<th>Pipeline classifier</th>
<th>Minimum distance classifier</th>
<th>Maximum likelihood classifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>vegetation</td>
<td>producer</td>
<td>user</td>
<td>Kappa</td>
</tr>
<tr>
<td>grass</td>
<td>76.75</td>
<td>66.75</td>
<td>0.583</td>
</tr>
</tbody>
</table>

Table 2 Accuracy of urban greenery extraction from SPOT-5 images

<table>
<thead>
<tr>
<th>class</th>
<th>Pipeline classifier</th>
<th>Minimum distance classifier</th>
<th>Maximum likelihood classifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>vegetation</td>
<td>producer</td>
<td>user</td>
<td>Kappa</td>
</tr>
<tr>
<td>grass</td>
<td>70.55</td>
<td>62.43</td>
<td>0.503</td>
</tr>
</tbody>
</table>

Quick Bird image  SPOT-5 image  TM image
Fig. 7 Visual interpretation result

Quick Bird image  SPOT-5 image  TM image
Fig. 8 Surprised classification result

Quick Bird image  SPOT-5 image  TM image
Fig. 9 Classification result based on object
Table 3 Accuracy of urban greenery extraction from QuickBird images

<table>
<thead>
<tr>
<th>class</th>
<th>Pipeline classifier</th>
<th>Minimum distance classifier</th>
<th>Maximum likelihood classifier</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>producer user Kappa</td>
<td>producer user Kappa</td>
<td>producer user Kappa</td>
</tr>
<tr>
<td>vegetation</td>
<td>54.55 52.48 0.453</td>
<td>64.34 48.91 0.466</td>
<td>69.21 63.53 0.603</td>
</tr>
<tr>
<td>grass</td>
<td>69.21 54.56 0.722</td>
<td>66.54 56.46 0.544</td>
<td>73.82 72.91 0.650</td>
</tr>
</tbody>
</table>

Table 4 Accuracy of urban greenery extraction based on the reference

<table>
<thead>
<tr>
<th>class</th>
<th>Urban greenery extraction based on object</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TM images</td>
</tr>
<tr>
<td></td>
<td>producer user Kappa</td>
</tr>
<tr>
<td>vegetation</td>
<td>82.46 86.63 0.844</td>
</tr>
<tr>
<td>grass</td>
<td>——</td>
</tr>
<tr>
<td>Total</td>
<td>83.35 87.56 0.843</td>
</tr>
</tbody>
</table>

One of the factors affected the accuracy is shadow, especial in QuickBird image, some of the shadow of building is divided into the vegetation. The use of vegetation index also is hard to eliminate the impact of the shadow. Therefore, it is necessary to eliminate the influence of the shadow as possible.

The difference is evident considering the statistic of diversity of images. The statistic of QuickBird image is different from that of TM or SPOT. It fluctuates drastically, which means it has no statistical meaning. But the statistical meaning of TM and SPOT image is evident.

Compared the greenery extraction from different sensors images on accuracy assessment, feather selection, multi-scale segmentation, classification methods, and affected factor and so on are all need to be considered.

4. Conclusion

By comparison, applying the high resolution Quickbird images to extraction greenery is acceptable. Judging from the method of the extraction of information, visual interpretation, statistical method and object oriented algorithm all have significance; visual interpretation is precise and reliable yet with low efficiency. Statistical method has a high efficiency yet with a low accuracy in high resolution images. The object-based algorithm is desirable for all sorts of images, but has a strict requirement on the choice of features. It is important to choose the right features to apply to classification. In conclusion, from the angle of extraction of information, it is insufficient to depend only on one method. All the methods should be united in order to obtain satisfied greenery information with high accuracy.

5. References
