A Web-based Spectrum Library for Remote Sensing Applications of Poyang Lake Wetland

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Abstract
Although the development of spectral library is a hotspot at home and abroad since 90's in 20th centuries, there isn't a suit of accessible spectral data of Poyang Lake wetland and it can't meet the demands of theory research and application of remote sensing in typical wetland protection and development of Poyang Lake nowadays. Aiming at establishing a practical spectral library of Poyang Lake's wetland (including hydro-physic community, swamp and grassland etc.), wetland spectra and their environment parameters and application models are integrated based on web techniques. The research concentrates on the description of spectral data measurement method, store & organization, realization of querying and presentation and web-interface design. It offers the details of regional featured spectra and an application demonstration of remote sensing identification model for wetland type, which provides large convenience for research fellowship in quantitative remote sensing.
Keywords
spectral library, poyang lake, remote sensing, classification, wethand type

I. INTRODUCTION

Internationally, the foundation research of remote sensing has developed more deeply and extended since 90's in 20th century, the band range involved is wider in spectral library, the spectral resolution is more elaborate, object types are more abundant. The development of standardized spectral library in remote sensing has already developed towards network share gradually[1–3]. Especially recently, with the fast economy developing and the need of sustainable environment development, the dynamic, practical and exact spatial spectral information are required. So, this offers the chance and challenge to the development of spectral library of remote sensing applications.

In the investigation and research of wetland resources, traditional field sampling method covers less area, spends more time and also destroys environment of wetland (Phinn, et al., 1999). However, remote sensing data has the characteristic of extensive area coverage, abundant information and quick updating cycle, and remote sensing method has no influence on wetland, so remote sensing technology has been adopted widely all over the world(Kumar, et al., 1994; Macdnald, et al., 1980; Waite, et al., 1971; Butera, et al., 1983; Li, 1998). Based on remote sensing technology, the distribution, growth condition and change of wetland biology resources can be estimated, and satisfying results have been acquired(Zhang, 1996; Ding, et al., 1984; Liu, et al., 1984; Browder, et al., 1989). Object spectrum reflects the most intrinsic character of wetland objects, so it is very necessary to study spectral character of wetland objects while distinguishing varied wetland types from remote sensing image. However, due to similar spectral characteristics of wetland, cropland and forestland(Houhoulis, et al., 2000) and difficulty of classification of different wetland types, the research of spectral character of wetland still emphasize on single wetland type or area estimation. For example, in Poyang lake area, Chen, et al. studied spectral curve of different wetland objects and surveyed the wetland area variation and distribution(lake , river , grass moor, mud flat , sand beach etc.) based on MOS-1 MESSR image. Zhou et al. analyzed the spectral characteristic of lake water, using five channels of NOAA satellite. Classification research on wetland is the precondition of remote sensing applications of wetland. Nowadays, the common classification methods are as follows: (1) Combining multi-bands remote sensing information, first exclude all other land types except wetlands through the pseudo color composite image of TM3,TM4 and TM5. Then combining with the pseudo color composed image of TM5 , TM6 and TM7 , and finding out the outlines of wetlands., thus different wetland types can be mapped(Zhang, et al., 1999); (2) Combining multi-temporal remote sensing information. The seasonal difference of landscape referring to the phenological phase of wetland vegetation is not similar to that of other natural vegetation or artificial vegetation. This difference makes wetlands difficult to be distinguished in summer and has utterly different characteristics of spectrum in spring and fall(Zhang, 2000; Zhang, et al., 2000; Dwivedi, et al., 1999); (3)Combining different sensor images, which involves remote sensing images of different spatial resolution, temporal resolution and spectral resolution. Kushwaha et al. combined ERS-1 SAR, IRS-1B, LISS- II and TM image to classify the wetlands of the Sundaban Delta(Kushwaha, et al., 2000).

In the nineties of the twentieth century, wetland spectral

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experiment was carried out in Poyang lake under the guidance of China Academy of Sciences. However, MOS-1 and JERS-1 satellites which spectral calibration was aiming at, had been stopped in operation in 1996. On 20th, Dec, 1995, Zhang, et al. measured spectrum of soil and vegetation using field spectral instrument SE5900, and established a nonlinear spectral mixing model of soil and canopy in Poyang lake area, the theoretical results of which were in good correspondence with the measured field mixed spectrum, but it is a pity that these data wasn't properly packed up. In order to provide information for monitoring, protecting and exploiting the lake beach vegetation in Poyang Lake of China, Peng, et al. carried out a study of the vegetation by means of RS technique (Landsat7 ETM +) combining GPS technique with GIS technique and the total distribution area and biomass of the vegetation were estimated by empirical model. Chen et al. found that the application of MOS-1 MESSR image was effective in surveying the variation of wetland area and distribution (lake , river , grass moor, mud flat , sand beach etc.) and discussed the spatial distribution characteristics of different wetland types in the studied region. According to the visual interpretation of Landsat TM images, Zhao et al. found that the area of low-grassland in 1999 in Poyang Lake region was 776.2 km^2 which was 124 km^2 larger than that in 1991 ,with 630. 9 km^2 of the grassland. Some specific measures were put forward for the synthetic utilization of the low-grassland and the control of the *oncomelania* and blood fluke disease. Based on the interpretation of two Landsat images , characters of land cover dynamic change in typical wetland area of Poyang lake had been discussed , and results indicated that terrestrial and aquatic interaction , human activity and light and heat condition were the main driving factors to the wetland cover change(Mao et al., 2006). In order to extract vegetation coverage from remote sensing data effectively, Wu C, et al. improved the two existing parameters derivation in equinoctial model of picture element, and built the new model to estimate vegetation coverage by NDVI, and estimated vegetation coverage of Poyang lake area in 2003. The estimated result was close to the field investigation.

The Poyang Lake is an international important wetland. However, lacking spectral library of wetland of Poyang Lake is a fatal problem for protecting, exploiting and inspecting quickly the wetland of Poyang Lake by quantitative remote sensing method. Therefore, with the support of the key lab of Poyang Lake ecological environment and resource development. Spectral library of Poyang Lake wetland is built by collection of environmental data, field measure(including the spectral data) and acquiring of remote sensing data and application demonstration of spectral library is developed in the flooded plain area of Poyang Lake. The featured objects of hydrophysic community, swamp, grassland and alluvion etc. , such as *Carex, P.hydropiper, Arte misia selengensis* and *Phragmites communis* etc., are selected as the main content of spectral library building, featured by fitting together well of object framework, spectral and model library, aiming at solving the problem existing in the application of remote sensing in Poyang Lake wetland area before. In the process of designing, the information safety and shortcut, strong functions, advanced technology, friendly interface, dynamic updating and other characteristic are taken into account. The spectral library is based on Internet/Intranet techniques, so it provides the convenient share of spectral information. The spectral library can enhance service ability for wetland protection and resource development of Poyang Lake.

II. CONCEPT DESIGN

The research established a standard, practical and multifunctional database, which contains the spectral data of in-situ and image of featured objects of wetland objects, Poyang Lake. The spectral library also contains the measured and processed circumstance parameters and background materials of featured objects. It deals with the relevant measured instrument description. Image library mainly contains spaceborn multi-spectral image. So the system can improve the use efficiency of spectral library greatly, offering the efficient management, querying and analyses of various spectral data, also being able to extend and mimic data in terms of users' need. Therefore, it provides convenience for research of spectral characteristics of wetland objects, serving for the analysis and forecast of wetland information of Poyang Lake. The system is composed of five parts: the knowledge database, measured hyper-spectral and image spectral library, remote sensing model database, spectral analysis, and application demonstration for the *Carex* identification. The goal of the system is to set up a spectral library that fuses spectral data, image data and application model.

III. ORGANIZATION OF SPECTRAL DATA

Data is core of spectral library. The major goal of the system in term of data descriptions is to efficiently manage and use spectral data within one single relational database example. So, it is a key of spectral library design how to logically organize different spatial dimension, multi-temporal, and spectral resolution data according to the requirement of wetland protection and exploitation. The spectral library of wetland of Poyang Lake mainly includes featured objects of hydro-physic community, swamp, grassland and alluvium etc. and the featured objects include sub-level objects, such as grassland is composed of *Carex, P.hydropiper, Arte misia selengensis Hydrocotyle sibthorpioides, Hornwort, Miscanthus sacchariflorus, Acorus calamus* and *Phragmites communis* etc. in the library.

Data models formally describe the way in which information in databases is organized. A common representation for a data model is an entity-relationship diagram(Date, 1995). In this article, entity properties are referred to as attributes with associated metadata content. A set of attributes of one entity is called an instance of that entity.

Figure 1 shows the data model framework of the library. Spectral information is systematically divided into nine thematic entities, each of which covers a different aspect of the spectrum description.

Each instance in the Spectrum entity is exactly related to one spectrum, and uniquely related to one instance in each entity. On the contrary, the relation between Spectrum and other instances is non-unique. In other words, Spectrum is linked to the other entities by n, namely, one kind of relationship, enforced by referential integrity constraints (foreign keys). The relations are in the third normal form to guarantee the consistency and minimize the redundancy of the data. This normal form requires for each entity to have the compulsory key attributes (family not null), specifically defined foreign keys, and uniqueness constraints that applied to the most relevant attributes, as denoted in Figure 1. Additionally, data system of spectral library of wetland of Poyang Lake is composed of in-situ hyper-spectrum data, prior knowledge and remote sensing image data. As it is well known, it is difficult to transfer image data to users on Internet. So, we construct fast-view image library, and users can evaluate and select image data by itself. After getting the authority, the users can download the desired data.

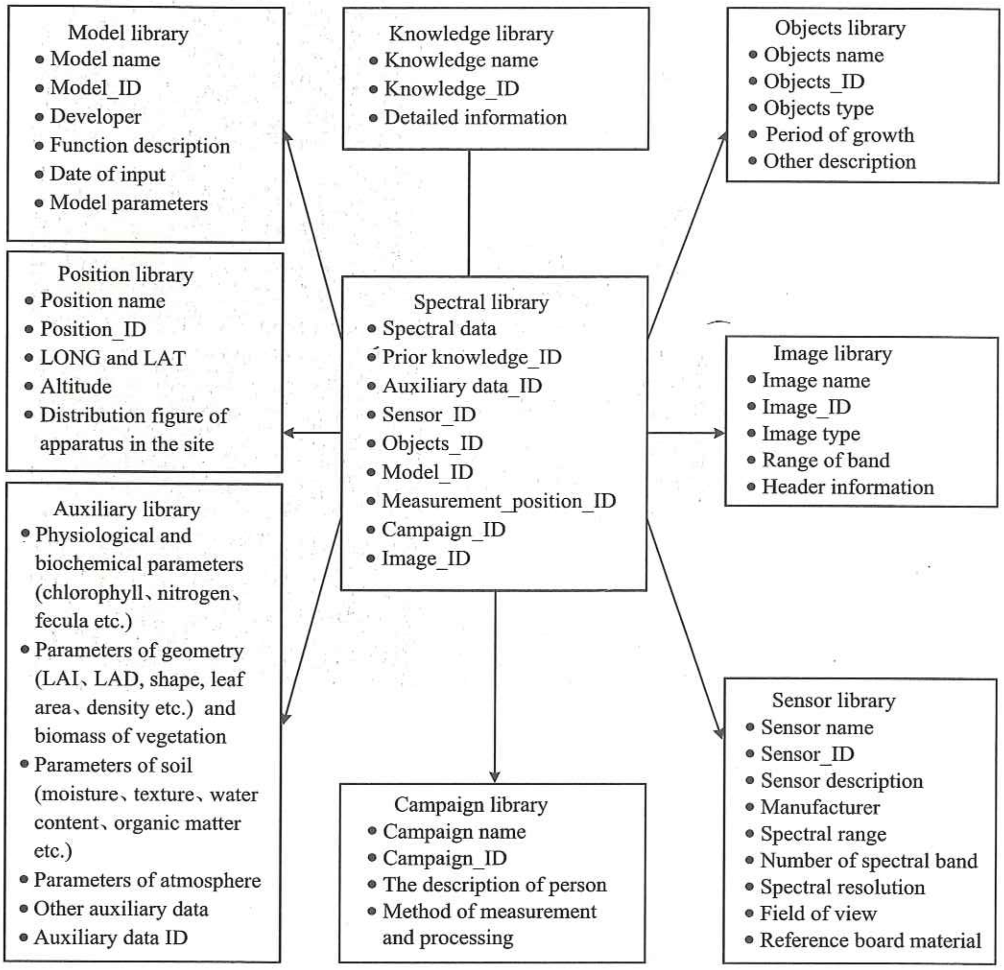

Figure 1. The data model of Spectral library of Poyang Lake wetland objects

IV. DESIGN of SYSTEM FUNCTIONS

The system aims at collecting spectral data and corresponding background material parameters of different growth periods of important wetland vegetation in Poyang Lake, providing management, query and analysis of spectral data of wetland for users. Particularly, the spectral based grassland area monitoring demonstration of Poyang Lake is presented for the convenient use of spectral library to varied users. Major functions of system are as follows:

A. Management of data

The database management system adopted component mode of C/S and B/S with an optimized structure of database, and realized a good interoperability and information share of heterogeneous platform. Operation and programming of users is all client, including management of spectral data, web pages, catalog, users, event monitoring, trouble recovery and buffer management. The system provides input, update, delete and output of data by a visual interface. In addition, the system provides the backup and recovery of database in case of data losing aroused by contingency and can backup data regularly (Shi-xuan, et al., 2000).

B. Query of data

For diversiform type of wetland objects in the spectral library (Figure 2 displays some objects of grassland), the system provides a visual interface for users to input query parameters, and returns the spectral data and image according to users' specification. There are two major modes of query, spectral query of wetland objects of different seasons and its image. The former function consists of measured spectrum query, image spectrum query and environmental parameters query. Particularly, the system offers a two-scale spectral query of canopy-pixel level, and it gives excellent help for users' contrastive analysis(Figure 3).

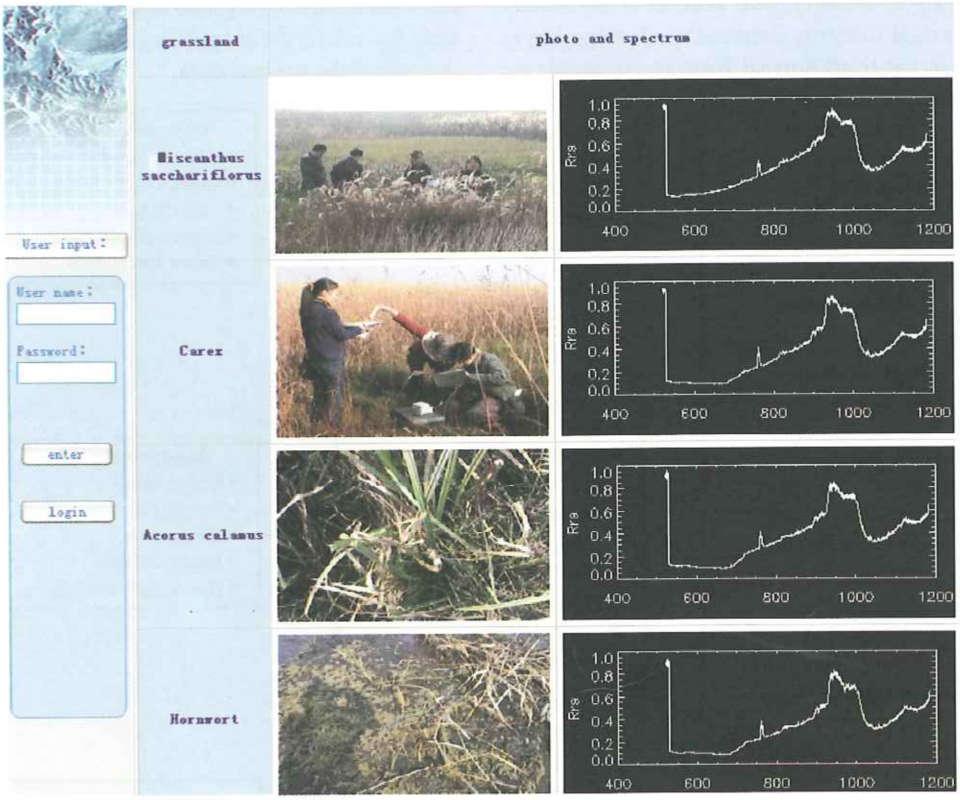

Figure 2. Several typical grassland objects in Poyang Lake wetland

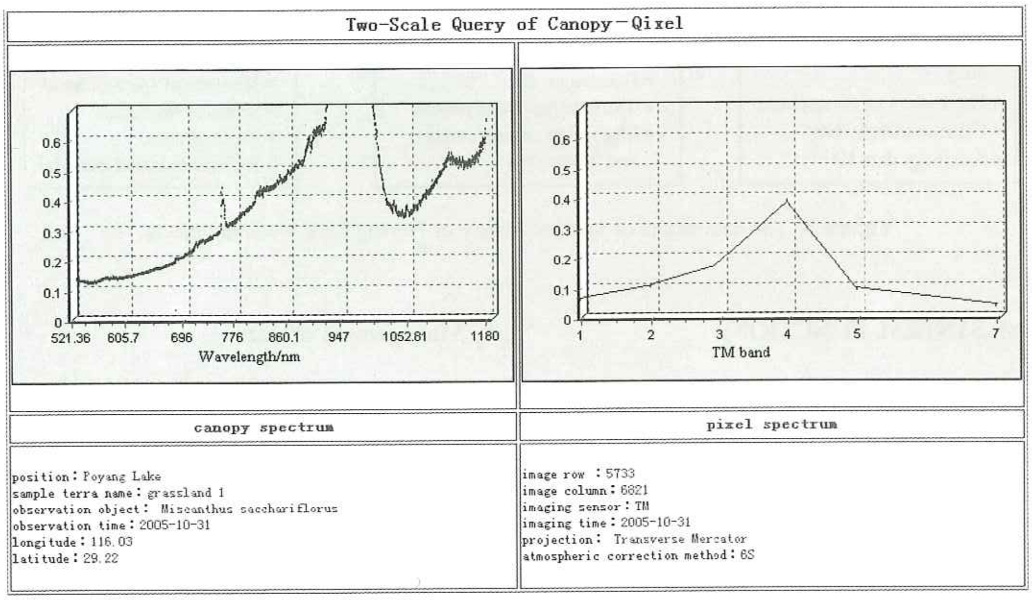

Figure 3. Two-scale query of canopy-pixel spectrum

C. Analysis and processing of data

The library of model is also a necessary part of spectral library. The system provides remote sensing reversion model of important wetland objects. Users can validate model and reverse result of wetland objects by remote sensing data within the spectral library, extend and interpolate spectrum of pixel from visible light to mid-infrared by remote sensing mechanism model and computer simulation model(Jacquemond, 1990). The system can extract object spectrum of different illumination, observation and atmospheric conditions, and execute two-scale conversion between canopy pixel level. The spectral library includes two kinds of models: spectral simulation model and spectral application model. Now, there is only spectral application model in the spectral library of Poyang Lake wetland, including characteristic spectral exponential model and spectral identification model of typical objects, such as *Carex*.

In addition, the system collects relevant waveband response function of TM, MODIS, AVHRR, HYMAP and Hyperion, according to users' need of contrast analysis; the system has ability of transformation from measured hyper-spectral data to corresponding waveband bandwidth of sensor. Besides, the system has functions of statistical analysis; users can draw image data histogram and all kinds of spectral curve of objects.

V. APPLICATION DEMOSTRATION PLATFORM

The dynamic spectral library of wetland objects of Poyang Lake is built to carry out real-time monitoring of objects species, area and environmental condition of wetland, and provides reliable data foundation and model parameters for building and validating of various remote sensing inversion and lake process models. Thus, the application of remote sensing technology is promoted in different direction, such as the relation between the area of grassland and water level of Poyang Lake.

Spectral identification model of typical objects of Poyang Lake wetland is chose to classify *Carex* and make area statistic in the application demonstration of spectral data such as migratory bird habitate protection. Figure 4 presents spectral identification model of typical objects of Poyang Lake wetland, in which classification rules are decided by expert knowledge. For TM image, the classification rules include TM band images, NDVI, DEM, the prior knowledge and the texture information etc.. According to figure 4, the classification approach of *Carex* is as follows:

- First, classification rule K1 {TM5 $>T_1$; TM7 $>T_2$} is obtained. Two infrared bands of TM image: TM5 and TM7, which are sensitive to borderline of water and land, can be used to distinguish water and land. The values of T_1 and T_2 are obtained by query and computing of spectral library or image.

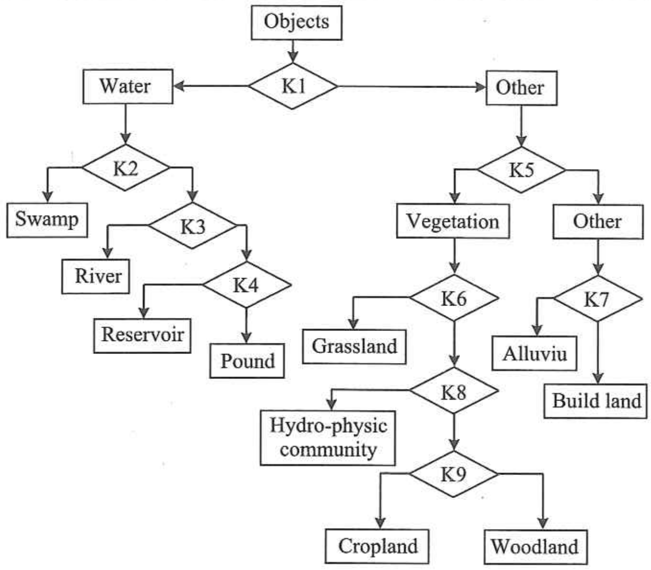

Figure 4. Spectral identification model of typical wetland objects in Poyang Lake wetland

- For classification rule K5 {NDVI $>N_1$}, NDVI is defined as the ratio of the difference between near-infrared band and red band of visible light to the sum of the two band values, i.e. NDVI= (TM4-TM3)/ (TM4+TM3), and experienced researches indicate that NDVI is an optimal indication factor to growth state and cover degree of vegetation including *Carex* in Poyang Lake wetland. The value of N_1 is obtained by query and calculation of vegetation pixel spectrum in spectral library of wetland.
- For classification rule K6 {TM2= (T_2, T_3) : NDVI= (N2, N3) ; the scope of latitude and longitude; texture information} .The method of acquiring values of T_2, T_3 and NDVI is the same as process 1 and 2. The scope of latitude and longitude is acquired by prior knowledge (such as wetland vegetation and upland vegetation can be distinguished by the flood plain area mapping); texture information is also prior knowledge. Usually, croplands can be removed from vegetation which have the approximate spectrum and DEM information according to **block-like figure** and larger area.
- The images have been preprocessed (radiance, atmospheric calibration and geometric correction) according to the requirement of spectral library. The demonstration uses Landsat TM remote sensing image with imaging date being on OCT. 31, 2005 and spatial resolution of 30m×30m. The TM image is classified based on above-mentioned classification rules, and then *Carex* area is extracted and calculated (Figure 5).

Figure 6 presents classification accuracy assessment.

VI. CONCLUSIONS

In order to meet the remote sensing application need for the spectral library of wetland objects of Poyang Lake, the

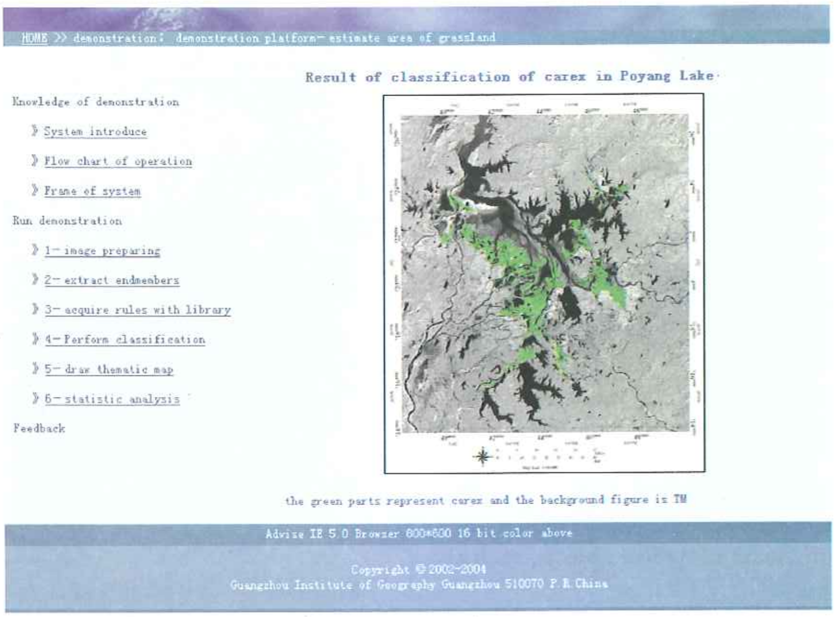

Figure 5. Result of *Carex* area estimation in web interface

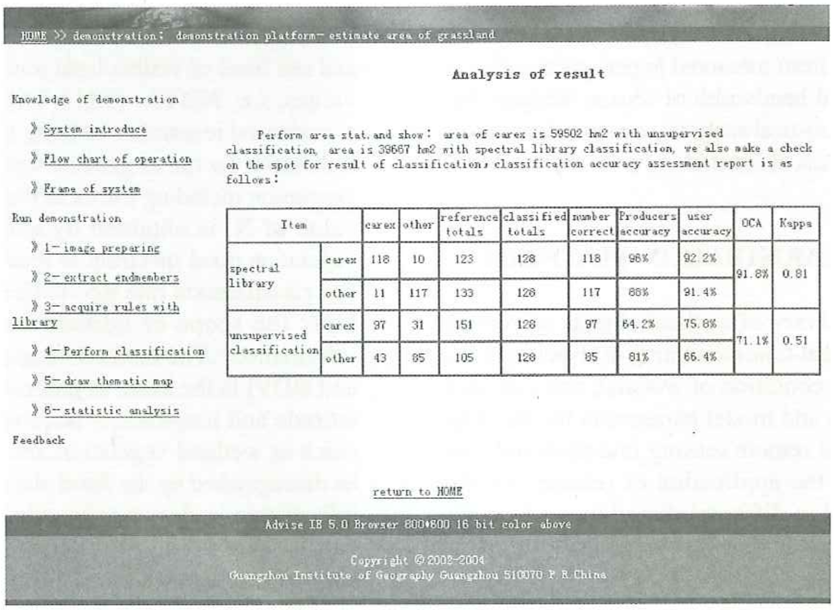

Figure 6. The evaluation of demonstration classification accuracy

research concentrates on the concept design of data organization, querying and presentation of spectra, user interface and so on. With the visual interface based on Internet, users can input the spectral data and query one or more spectral curves, including the corresponding metadata. Using Internet, the C/S structure-based system frame provides spectral information service in the mode of text, form, figure, image or their combination. Particularly, the spectral based distribution area monitoring demonstration of *Carex* is presented for the convenient use of spectral library to varied users. Therefore, the appliable of wetland spectral library is improved greatly, and it has definite guidance meaning for spectrum-based remote sensing application, which improves the abilities of spatial information acquiring, processing and applying in remote sensing monitoring of Poyang Lake wetland. It is expected to exert a better effect on in-depth exploitation of remote sensing information and industrialization of spectral data, bringing new chance and challenge for research and exploitation of Poyang Lake wetland in Jiangxi province, China.

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