THE SURVEY OF ACCURACY ANALYSIS OF REMOTE SENSING AND GIS

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ABSTRACT:

With the fast development of cities in China, more and more geographic information systems (GIS) that have been combined with remote sensing information are applied to help decision-maker or company to manage and make macroscopic decisions. But the accuracy of integrated GIS was ignored by both user and producer. It followed that the uncertainty of GIS may result in wrong decision. For these reasons, it is necessary to evaluate and analyze the accuracy of GIS and remote sensing information.
In this paper, the general situation of integrated GIS in Shanghai was introduced, uncertainties of GIS and remote sensing were demonstrated, and where uncertainties exist in and what cause more uncertainties in the course of producing GIS were analyzed.

1. INTRODUCTION

Good science requires statements of accuracy by which the reliability of results can be understood and communicated. Where accuracy is known objectively, then it can be expressed as error, where it is not, the term uncertainty applies (Hunter and Goodchild, 1993). Thus, uncertainty covers a broader range of doubt or inconsistency, and error was viewed as a component in this paper. Of course, we can see uncertainty in the course of merging remote sensing and geographic information system (GIS). Under common circumstance, however, people who produce GIS as a production were reluctant to pay more attention to this problem, and the user is nearly blind to this problem. Therefore our overall goal with this paper is threefold: (i) to introduce the current situation about GIS which is combined with remote sensing information in Shanghai, (ii) to analyze the causes of the existence of the uncertainties from remote sensing and GIS, and (iii) to communicate these problems to the user and the same trade, then in the long run to find a perfect way to resolve it.

1.1 Remote Sensing Information and GIS

Remote sensing information includes various kinds of platform data. It is an abundant, short period, macroscopic, dynamic information resource. GIS consist of computer hardware, software and data. They are designed to efficiently capture, manage, analyze and display all sorts of spatially referenced information. It is GIS that can gives the user complete freedom of combining, overlaying and analyzing data from many different sources. Merging remote sensing information and GIS, on the one hand, can improve the accuracy of capturing and classing remote sensing image, raise the level of qualitative analysis and quantitative analysis of remote sensing information; on the other hand, can be a steady information source for continuously updating the database of GIS, holding the effective use value and the dynamic analysis function of GIS.

1.2 Current Situation of Shanghai

With the rapid development of the metropolis, GIS is being required to provide services in more and more fields, such as urban economical construction, planning and management. The urban GIS also make life convenient when people live through the internet. Thus, many GIS companies with GIS production spring up in Shanghai and China. Generally, they hope their users use the GIS production without any regard for the accuracy characteristics of the data themselves and regardless of scale, accuracy, resolution and quality of the original map documents. As a result, in fact, most users ignore the accuracy.
In Shanghai, most GIS depend on many kinds of data sources, such as:

Airborne remote sensing image, scale 1:10000 or 1:50000.
Satellite remote sensing image.
General location map, or digital map with local coordinate.

The simply constructed continuum was illustrated in Fig. 1.

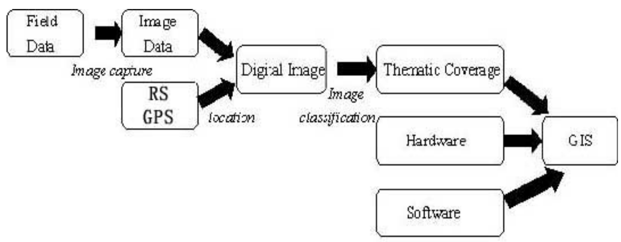

Figure 1. Continuum of abstraction of the GIS producing process.

Thereinto, **thematic coverage** includes location map, traffic situation map, afforest distributing map, urban construction situation map, water resource distributing map, land resource distributing map, urban geology map, underground excavation map, hazard map etc..

And in the context, we will analyze the uncertainty among these sources.

2. UNCERTAINTY IN REMOTE SENSING INFORMATION AND GIS

Being an important data source of GIS, accuracy and quality of remote sensing data will directly affect the quality of GIS. So when we analyze the uncertainty of integrated GIS, we must consider from the both two sides.

2.1 Accuracy and Quality of Remote Sensing Data

About remote sensing information, resolution, uncertainty from the course of image gaining and digitizing, interpretation accuracy were addressed.

2.1.1 Resolution

Different GIS may choose different kind of remote sensing information, such as aerial photography, satellite remote sensing information. Since 1981, 9 times of aero-photography have been involved in Shanghai. The latest one is in 2000, its task involved in color infrared to advance comprehensive research and provided two basic scale: 1:10000 and 1:50000 (Table 1). Even the remote sensing data from different satellites now has been adopted with various resolution (Table 2).

Image scale & resolution / scanning density	1：10000 resolution	1：50000 resolution	File size save as TIFF format (MB)
1500dpi	0.17m	0.85m	530
1200dpi	0.21m	1.05m	340
1000dpi	0.25m	1.25m	240
600dpi	0.42m	2.10m	85
300dpi	0.84m	4.20m	22

Table 1. Different resolution when two scale image scanned in different density.

Accuracy of GIS is affected directly by the resolution of interrelated remote sensing information. And there is always a dilemma when we want to choose an ideal resolution of remote sensing image for GIS and maintain the high efficiency of GIS simultaneously. High resolution means more detail information available, however, it is difficult for most GIS to quickly deal with the large amount of data given by high resolution now. Furthermore, a pixel which mixing various information at low resolution can not change into one which expresses simple information at high resolution. So the scale of GIS was determined by the interactive and different aims.

When we integrate GIS with multi-spectrum multi-time facies and multi-altitude remote sensing data of one area, we can gain more information than with any single one. Another problem merits attention, not considered seriously here, is that to do such things have to involve the studies of accuracy.

2.1.2 Uncertainty from the Course of Image Gaining and Digitizing

As we all know, in the course of producing digital remote sensing image, there are also many errors produced. As airborne remote sensing is a main mean to gain image in Shanghai, we take it for instance here. In the table 3 as following some common uncertainties and interrelated information about these uncertainties are lined up.

Satellite	Sensors	Bands(number of channels)	Resolution (m)	Period
Landsat-5	MSS	Multi-spectrum(4)	80	16days
	TM	Multi-spectrum(6)	30	
		Multi-spectrum(1)	120	
Landsat-7	ETM+	Panchromatic (1)	15	
		Multi-spectrum(6)	30	
		Multi-spectrum(1)	60	
Spot-2	HRV	Multi-spectrum(3)	20	26days
		Panchromatic (1)	10	
Spot-4	VI	Multi-spectrum(4)	1150	
	HRV	Multi-spectrum(4)	20	
		Panchromatic (1)	10	
IRS-1B	LISS-I	Multi-spectrum(4)	72.5	24(5) days
	LISS-II	Multi-spectrum(4)	36.25	
IRS-1C, IRS-1D	WiFs	Multi-spectrum(2)	188	24days
	LISS-III	Multi-spectrum(3)	23	
		Multi-spectrum(1)	70	
	Pan	Panchromatic (1)	5.8	
IKONOS	Pan	Panchromatic (1)	0.82	14days
	MS	Multi-spectrum(4)	4	
CBERS-1, ZY	CCD	Multi-spectrum(5)	20	26days
	IRMSS	Multi-spectrum(3)	80	
		Multi-spectrum(1)	160	
	WFI	Multi-spectrum(2)	260	

Table 2. The parameter of some satellite which can be applied in urban area.

And another possibility that merits attention here is that when these digital images with errors applied in GIS, errors may spread and more uncertainties may emerge.

2.1.3 Interpretation Accuracy

To make a thematic coverage or gain geographic objects, we must form geographic classes or objects from image data. Whether we use eyes or various models of different software can both effect on the uncertainty properties of data. It may result in inaccurate properties of data, or differ logically among data.

Kind of accuracy	Uncertainty	Notes
Scale	Inherent errors, such as projection error	Mono-projection cause different scale at different place in a single image, it need digital geometric correction
	Flight error, such as inclination error, yaw	When the flight's bank angle (camera angle) more than 3 degree, the image's scale is not we hoped for. When yaw appeared and the flight missed some place, it must fly again.
	Uncertainty caused by instruments	If we don't examine instruments with precision, they also make some scale departures, e.g. deviations of the focal distance in a aerial camera
Location	Location error	Control points were applied to locate remote sensing image, the number and accuracy of the control points certainly affect the accuracy of location.
	Correction error caused by accuracy of model of different software	After we choose several geodetic control points to locate image, computer takes the task to calculate. Different software has various models with distinct accuracy. Which is the best model for it?
Resolution	Scanning error	It includes accuracy of scanner and set-up in the course of scanning.
Color	Chromatic aberration	Aerial photography is liable to be effected by atmospheric emission or air-borne circs. Therefore, chromatic aberration appears.
	Correction uncertainty	If unsuitable model is use to correct chromatic aberration, more uncertainties spring up. We are unable to assure which color is the true.

Table 3. Some common uncertainties in the course of image gaining and digitizing. In this table we also can get interrelated information about these uncertainties.

2.2 Map Data

As to GIS, we focus on map data. The reason is that the present GIS in Shanghai are founded on the base of local map with geodetic coordinate. Map is the standard data which we recognized conventionally. But come seeing from the process of manufacturing map, we find all the concrete things on the ground were converted to systemic symbolization. Many detail such as the spatial of the object were curtailed, when we make decision especially for the urban construction, planning or management, it cannot offer an effectual reference. Therefore we can say the accuracy of the map cannot only measure with scale. Compared with remote sensing information, the latter's ability of imaging spatial features is far better than map's. Thus, from this angle, we can take it for granted that the GIS integrated remote sensing image was more accurate than that only founded on map data.

Besides above-mentioned thought, other three aspects would be considered. Firstly, the accuracy and quality of the map or digital map is the point at issue we focus on. Both airborne remote sensing images and satellite remote sensing images are finally combined with local map data in GIS. However, users and producers may pay no attention to this point. Second is the timeliness of the map. Sometimes, GIS producer used obsolete map data. Perhaps they had no idea that the city developed so rapid that many basic elements such as road, river and pond have changed. Finally, is a question: when we combine the two kinds of data (image data and map data), which is the best model we can use that can make the less uncertainty? We have not a specification and best scheme for it, at least for now.

3. UNCERTAINTY FROM THE PROCESS OF INTEGRATING GIS AND REMOTE SENSING INFORMATION

We know there are uncertainties in the process of integrating GIS and remote sensing information. There have also three aspects: (i) the errors from data transition and calculation, which have been studied by many professionals for a long time; (ii) data updating, which is ignored by GIS producer, especially when we find a street or a bus-stop in the electronic map of internet no longer corresponding to the status quo; (iii) uncertainty spreading, if we apply different models to make decision or analyze, uncertainty will spread, even lead to wrong results. Therefore, uncertainty in different models for analyzing spatial data will affect reliability of GIS.

4. APPLICATION AND PROSPECT

As metropolis in China like Shanghai is in a key developing period, a kind of integrated GIS based on RS information is needed to play the role of platform called conformity-congregate information field that can assist us to save, manage, analyze and apply city spatial data information. The system is not a simple platform based on topographic map, but a complex one full of integrated information based on RS image data. It can be shared by government and all kinds of businesses. Therefore, the application of accuracy evaluation of integration of GIS and remote sensing is of great concern. Accurate integration information set the seal on reliability of the platform. At present, integration of remote sensing information and GIS can differentiate theoretically three levels: separate but parallel combination, seamless combination and solid integration. The third level means an integration platform that includes data, function, interface etc., however, which we have not really achieved. So it is a necessary element to appraise correctly the accuracy of the integration of remote sensing and GIS, and promote the integration forward to higher level.

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