A GEO-CODE MODEL FOR THE USE OF GEOGRAPHIC INFORMATION SYSTEM

Professor Ma Ai Nai
The Institute of Remote Sensing
Peking University
Beijing, People's Republic of China

ABSTRACT

When thematic maps are stored in computer based Geographic Information System (GIS), a model must be built for processing. On the contrary, when systhetic maps are stored in GIS, a model must also be built.In either case, a model shall be represented by polygons and polygan may be identified by Geo-Code Model.

Geo-Code Model is a multi-digit code of geoscience model. For example, soil erosion Geo-Code Model consists of 7 digits; each digit represents soil erosion intensity, anti-erosion years, erosion type, soil texture, base level of erosion, elevation and vegetation coverage respectively.These data can be obtained from remote sensing images MSS, TM and topographical maps. The technique has been applied in China Soil Erosion 1 : 500,000 Scale Map, 6-digit code of land type and 20-digit code of land resources, etc.

INTRODUCTION

In the recent years, the Hi-Technology of Remote Sensing Information (RSI), Geographical Information System (GIS) and Geographical Expert System (GES) have been applied in geographical studies. The expression of geography tends to be formalized; qualitative description and quantitative data shall be unified. The objects of geoscience, sach as atmospheric, hydrologic , vegetative, sesotic (sediment and soil), lithospheric and geomorphologic material transportation, energy translation and information transmission, need to be processed by computer. A mass of geographical data need to be stored in electronic storage and processed by computer. This causes the concept of Geo-Code Model. This paper delivers my concept about Geo-Code Model based on my recent research. I also define two types of GCM and basic operational method.

ATTRIBUTE OF GRAPH

No matter it is a thematic map or synthetic map, every map has its own attributes. In 1935, G. D. Hudson made a suggestion of coded representation of land classification. By the time, it was difficult to use without computer and long range code. Even though G. D. Hudson condensed the code, it just made the model complicated. So this method has never been applied. Today, the computer technology has been widely used, geographical information system has been established and various models need a new general exeression: Geo-Code Model.

Geo-Code Model is different from Data Code Model (DCM) of graphical structure. DCM represents the boundary of map spot. There are vector structure and grid structure for DCM. The grid structure: equal-size code pattern, quadtree code pattern and k-dimension code pattern are tree type of DCM.Nevertheless, GCM is designed for representing the attributes of map spots.

The attributes of map spot could be qualitative characteristics from survey or quantitative data from observation. According to characteristics bound of geographical region, quantitative data and qualitative characteristics need to be unified in order of levels. It calls normolization both of quantitative and qualitative information.

For example, the Soil Erosion Map in 1 : 500,000 scale has seven digits in GCM. Each digit classifies several levels such as 3-level, 5-level and 6-level which is according as objects. Hence, the attributes and levels make up a two dimensions table. See Table 1.

Table 1: Soil Erosion Geo-Code Model

Digit Code	1st	2nd	3rd	4th	5th	6th	7th
Attributes / Levels	Erosion intensity T/km²·yr	Anti-erosion years yr	Erosion type dymamic	Soil texture 2cm%	Base level of erosion m	Elevation m	Vegetation coverage %
1	<500	>1,000	Water	>70	0	<50	>90
2	500-2,500	100-1,000	Wind	30-70	1,000	50-200	70-90
3	2,500-5,000	10-100	Frost	<30	4,000	200-500	50-70
4	5,000-8,000	1-10				500-1,000	30-50
5	8,000-15,000	<1				1,000-1,500	10-30
6	>15,000					>1,500	<10

Erosion intensity: 1=lowest, 2=lower, 3=low, 4=high, 5=higher, and 6=highest.
Antierosion years: 1=sufe, 2=dangerous, 3=more dangerous, 4=most dangerous and 5=damage.
Soil texture: 1=stony, 2=stony-soil and 3=soil.
Base level of erosion: 1=plain, 2=plateau and 3=very high plateau.
Elevation: 1=basin plain, valley, low lying land, 2=hilly land,platform, 3=low mountain, 4=middle mountain, 5=high mountain and 6=very high mountain.
Vegetation coverage: 1=highest, 2=higher, 3=high, 4=low, 5=lower and 6=lowest.

Every map spot has 7-digit. The appearance of a different digit forms another spot. The 7-digit could be acquired from among

remote sensing images (in the table 1: 3rd, 4th and 7th digits), topographical maps (in the table 1: 5th and 6th digits) and measured data of Water and Soil Conservency Stations (in the table 1: 1st and 2nd digits). Then we can input GCM with seven digits to computer for store. And we can also output different thematic maps according to user's need.

For example we can extract the 1st, 2nd and 3rd digits from the table 1 then constituted thematic map of different level erosion intensity and anti-erosion years in different erosion type.Such as:

321 = low intensity dangerous water erosion,
452 = high intensity damage wind erosion,
:
:

We can also extract 5th and 6th digits from table 1 then constituted geomorphological map. We can also extract 7th digit from table 1 then constituted vegetation coverage map and so on. If we extract all digits such as:

3212225 = low intensity, dangerous, water erosion, stony-soil texture, plateau, hilly land, lower vegetation coverage.

That is stony-soil texture plateau hilly land lower vegetation coverage low intensity dangerous water erosion.

TWO TYPES OF GCM

The thematic maps of geography have two types. One is according to classification of objects system such as landuse/cover map, soil types map, vegetation types map and so on. Their levels are made up tree GCM. The other is according to multi-index GCM such as soil erosion map, land type map, land resource map and so on.

1. Tree GCM

For example: we can only use one digit 9 kinds for 1:4,000,000 scale landuse/cover map, use two digits 33 kinds for 1:500,000 scale landuse/cover map. See Table 2.

Table 2: Landuse/cover Geo-Code Model

First Classification		Secound Classification	
1st digit	Kinds	2nd digit	Kinds
1	Cultivated	1	Paddy field
		2	Dry farmland
		3	Others
2	Garden	1	Orchard
		2	Mulberry field
		3	Tea plantation
		4	Others
3	Forest land	1	Forest
		2	Shrub forest
		3	Others
4	Grass land	1	Natural grassland
		2	Artificial grass

Continuing Table 2: Landuse/cover GCM

First Classification			Secound Classification	
1st digit	Kinds		2nd digit	Kinds
5	Residential area		1	City
			2	Rural
6	Work & mine area		1	Mining area
			2	Salina
			3	Others
7	Traffic		1	Railway
			2	Highway
			3	Airport
			4	Harbour
			5	Others
8	Water area		1	River
			2	Lake
			3	Reservoir
			4	Ice-snow
			5	Others
9	Nonuse land		1	Wasteland
			2	Saline-alkali
			3	Marshland
			4	Sand barren
			5	Gobi
			6	Others

There are 11 = Paddy field, 23 = Tea plantation. 71 = Railway, 95 = Gobi and so on. Of course, we can continue the third. the forth classifications, etc. In short, one digit, two digits or three digits they are only explained one kind object.

2. Multi-index GCM

As an example above Table 1 we could use seven digits for Soil Erosion Map. Next, we would like to give Land Type Map in GCM In general, there are climatic. hydrographic, vegetative, sesotic, geologic and geomorphologic facters in large Geographical Zone. So Land Type should be six digits GCM. That is:

```
*          *          *          *          *          *
:          :          :          :          :          :
:          :          :          :          :       geomorphologic
:          :          :          :       geologic
:          :          :       sesotic
:          :       vegetative
:       hydrographic
atmospheric
```

But in a small basin. if the area less than 5,000 square km,the climatic zone and hydrographic zone are same. Then the facters are sesotic, vegetative and geomorphologic facters mainly. That is 3-digit GCM.

```
*                    *                    *
:                    :                    :
sesotic texture   vegetation form   geomorphologic type
```

See Table 3.

Table 3: Land Type Geo-Code Model

Digit code	1st digit	2nd digit	3rd digit
Attributes Levels	Sesotic texture	Vegetation form	Geomorphologic type
1	Clay	Forest	Valley plain
2	Loam	Bush	Terrace
3	Loess	Grass	Hilly land
4	Sand	Forest-bush	Mountain
5	Gravel	Forest-grass	
6		Bush-grass	
7		Forest-bush-grass	

For example:

322 = loess bush terrace,
251 = loam forest-grass valley plain,
433 = sand grass hilly land,
:
:

In the same way, there are solar radiation, accumulated temperature, precipitation, runoff, vegetation type, vegetation coverage, soil type, soil depth, soil moisture, soil fertility, lithic contact, mineral type, mineral grade, mineral reserve, underground water, elevation, altitude, slope, longitude and lutitude 20-digit for Land Resource Map in general. But in a small basin it is simple. See Table 4.

Table 4: Land Resource Geo-Code Model

Digit code	1st digit	2nd digit	3rd digit	4th digit
Attributes Levels	Underground water depth cm	Sesotic depth cm	pH	Humus %
1	<30	>100	<4.5	>2.0
2	30-60	60-100	4.5-6.0	1.0-2.0
3	60-100	30-60	6.0-7.5	0.5-1.0
4	>100	<30	7.5-8.5	<0.5
5			>8.5	

BASIC OPERATIONAL METHOD OF GCM

Besides graphic simple logical operation (and, or, intersection) there are some main basic operational method of GCM.

1. Extraction

The arbitrary digits are extracted from GCM, then we could gain new facters maps. As an example if you would like to extract 1-

digit that is 7th digit of Soil Erosion Map, then you will gain Vegetation Coverage Map. If you would like to extract 1-digit , that is 1st digit of Land Type Map, then you will gain Sesotic Texture Map. As you require.

2. Composition

On the basis of extraction, we could renew a composition GCM and recreate a newly thematic map. As an example: we will recreate a new map for land evaluation of agriculture. We can extract the 1st and the 3rd digitsof Land Type Map, the 1st, 2nd, 3rd, and 4th digits of Land Resource Map, the 1st and 3rd digits of Soil Erosion Map. Then we can renew a composition an 8-digit Geo-Code Model. That is

```
 *       *       *       *       *       *       *       *
 :       :       :       :       :       :       :       :
 :       :       :      pH       :       :       :geomorphologic type
 :       : sesotic texture       :       : erosion type
 : sesotic depth                 : erosion intensity
underground water depth     humus
```

There are

The 1st class agriculture land use:

$$\binom{2}{3}\binom{1}{2}2311\binom{1}{2}\binom{1}{2}$$

The 2nd class agriculture land use:

$$\binom{2}{3}33\binom{2}{4}\binom{2}{3}\binom{1}{2}\binom{1}{2}\binom{1}{2}{3}$$

The 3rd class agriculture land use:

$$\binom{1}{4}\binom{3}{4}\binom{1}{3}{4}\binom{2}{4}{5}\binom{3}{4}\binom{2}{3}\binom{1}{2}\binom{1}{2}{3}$$

and so on.

3. Operation

We could make arbitrary operation, such as the following simple example: the soil erosion depth can be changed from soil intensity. Then

$$\text{anti-erosion years} = \frac{\text{sesotic depth}}{\text{soil erosion depth}} \quad \text{(years)}$$

and so on.

In brief, the Geo-Code Model is very useful for the knowledge of quality descriptive characteristic to change to quantity data (levels) with formalization and normalization. It will be the focus of GIS and GES.

REFERENCES

[1] Hudson, G. D.; The Unit Area Method of Land Classification, Invited Paper Delivered Before the Association at St. Louis, Dec. 1935

[2] Ma Ai Nai, Remote Sensing Images Visual Interpertation and Computer Assistant Map, The 5th Congress of National Society

for Remote Sensing, Guangzhou, China, Jan. 1988
[3] Ma Ai Nai, Zhang Xuding, Liang Zhengya and Li Yiqing, Study on the Soil Erosion Information System, Proceedings of International Workshop on GIS, Beijing, China, May 1987
[4] Ma Ai Nai, Sesosphere and Sesotic Resource, 1988