Practical Experience of automatic generalization for geo-spatial information

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Abstract

Early time of map data production was focused on efficiency process of paper map making. It is moved to production of geo-spatial information for GIS afterward GIS spreading. However the demand of paper maps remained high, therefor both of geo-spatial information for GIS and print data for paper maps are required to produce at once. But paper map is required to understand by human being, geo-spatial information is required to understand by computer (GIS), and those data structures are not compatible. Accordingly double compilation are required.

Therefor we developed a system that automatically generalizes structured geo-spatial information to make paper map.

1. Introduction

Human races are facing very serious problems such as pollution, global environment changing, food self-sufficient dropping and so on, because of increasing human activation by population explosion. Therefor production of geo-spatial information and spatial analysis of the information are indispensable matter to analyze these problems and to find methods to solve.

Beside most desirable countries of geo-spatial information are developing countries, and most lacking countries of geo-spatial information are also developing counties too. Few organizations control not only geo-spatial information at these countries, but also geo-spatial information can not fill every usage of paper maps. This makes that paper maps are also very important.

However unified production of geo-spatial information and paper maps are difficult (Terabayashi et al, 2000). And the lack of method for the unified production is an obstacle to fill geo-spatial information, such as production of only geo-spatial information could not show enough effects, or double processing of geo-spatial information and paper maps carries heavy burden.

2. Geo-spatial information and paper map

There is no unified production system of geo-spatial information and paper map, because of characters of geo-spatial information and paper map are very different.

The geo-spatial information are required to be analyze by GIS, and the paper maps are required to be understand by human being (Akeno, 1997). So that GIS has good function for spatial analysis, map publication system has good function for expression. This means those production methods of geo-spatial information and computerized paper map can not harmonize.

Then we took data on production phase as map data, then automatically produce print data and geo-spatial data (fig-1).

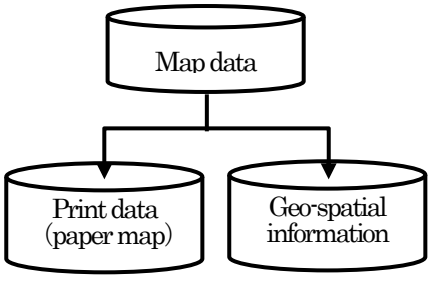

Fig-1 Data classification

3. Existing systems

The existing systems around map field can classify as “Map production system (CAD)”, “ Image processing system (Remote sensing)”, “Geographic information system (GIS)” and “Map publication system (Map publication)”.

Under these classifications, map production system is trying to fuse with GIS not strengthen portrayal.

Image processing system is increasing the data that are adaptable by GIS, because of the data formats are

standardized and the target data of processing is only image since the system itself has strong originality.

GIS is taking in functions of surrounding fields such as map production, image import and portrayal close to paper map expression. But these are not equal to unique systems, because of GIS's essence is spatial analysis. So that GIS dose not have enough ability of portrayal to replace paper maps which is sold widely.

Map publication system dose not considers connection with GIS, because it grew originally in field of map publication trade. Map adjustment trade field adapts combination of ESRI's Arc/Info and Adobe's Illustrator. Geographic Survey Institute of Japan (GSI) developed a system based on image data by themselves to realized same expressions of existing paper map (Akiyama et al, 1988; Ochi et al, 1994). Recently PCI of Canada that is known by image processing system and GeoConcept of France that is known by GIS are released map publication system such as ACE and Module Publisher. These has strong connection with GIS but the functions is mainly interactive generalization, so that double processing are hardly avoid.

4. System specification require

The realization of unified production method for geo-spatial information and paper map requires to solve problems "Commonage of geo-spatial data and print data", "Operation for character and symbol", "Opaque" and "Print data transmission to film printer" by automated processing on our study.

(1) Commonage of geo-spatial data and print data

Print data for paper map dose not regard the data structure since paper map applies human eyes to be used. But line weight, line pattern, symbol figure, character type and their colors to be adapted are strictly obeyed. The symbol intervals occasionally change according to size of plotting area. Also low portrayal order symbols have to opaque.

Geo-spatial information is strictly regarded classification, data structure, and topology for network and face since geo-spatial information applies computer processing. Nod data is occasionally required between line elements.

This means the characters of geo-spatial information and print data are very different, so that it is hard to satisfy the requirement from both of GIS and map publication.

(2) Operation for character and symbol

Character and symbol are expressed by font data. The data in the font file and map file have linkage numbers, since the font data that has figures of characters and symbols in the independent file.

However it is necessary to transfer the font file at a time, in case of map data files are transferred to other computer. But Windows can not distinguish characters of every language, since character fonts depend upon the computer operating system. Therefore figures of font can not transmit to another computer that adapted different language's operating system, even though the font file itself has been moved.

(3) Opaque

Map data is displayed in appearance order at GIS and CAD, or some system can reserve by bundles. Therefore expression of output map data is not always same as paper map.

This means either highest portrayal order data must be selected or lower portrayal order must be deleted at the places of symbols are overlapped. And it is happened symbols that expressed area have to penetrate lower portrayal order data according to the rate.

(4) Print data transmission to film printer

DTP (Desk Top Publisher) is now spread not only book publication field but map publication field to make reproduction films for map printing. And these are almost built on Macintosh computers. The architecture of computer between Macintosh and Windows is very different. Accordingly transmission of vector data such as font or complicated structure between Macintosh and Windows without any loss of information is very difficult.

5. System development

We decided that it is proper production process to build the method as print data is processed from map data which commonly used between geo-spatial information and print data, as the result of our study for unified production method of geo-spatial information and paper map (fig-2).

5.1. Commonage of map data (structuring for print data)

At processing to make print data from map data, some of the symbols according to symbol legend are plot

on area. This means polygon that indicate the symbol area have to be created automatically.

In case of polygon is already exist, the polygon must be classified as which area is indicated.

In case of polygon can be created automatically, a symbol is necessary to indicated the area. This allows linking between polygon and symbol. And automatic polygon creation requests lines that are tied by coordinate or have topologies. Or lines are divided at crossing, if not it is necessary to be divided in advance.

5.2. Generalization (automation)

The problems for automatic print data production from map data that generalized are solved as below.

(1) Production for reproduction film

Raster format is adapted to transfer from Windows to Macintosh without any lack of data information.

(2) Opaque

Opaque is realized by converting map data in opposite portrayal order when raster data is created. This means that map data is more proper to be sort in opposite portrayal order in advance.

(3) Operation for character and symbol

Font of annotation character and map symbol are converted to outlined elements such as lines and polygons.

(4) Symbolizing

It is proper to symbolize map data as same as paper map according to map legend before creating print data.

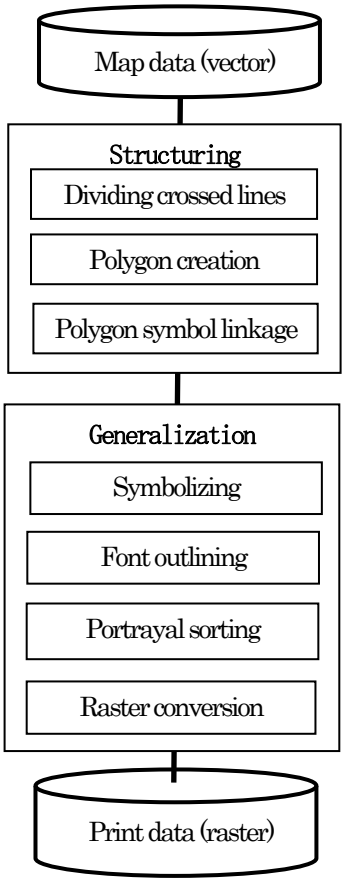

Fig-2 Process flow

6. Realization of generalization

6.1. Basic structures of map data

Basic structures of map data are classified as point, line, polygon, symbol, character and image.

And under the expression of map publication, the point is estimated length less line or size less symbol, character and symbol are estimated as same architecture as font, and image is out of estimation because of expression form is not necessary to change. This means the data structure for expression of map publication is enough by a line, a polygon and a font.

6.2. Generalization method

Symbolizing for lines, polygons and fonts are realized as below (Goto et al, 1999).

Lines are adapted various line patterns, also various symbols are stacked along the lines according to map legend. Compound lines such as colors are different on edge and inside are transferred to edge lines and inside polygons for example.

Polygons are divided an edge line and an inside polygon. And the edge line is operated as same as lines. The inside polygon is plotted various point symbols as grid, totter, curve position, and also various grid lines. The origin coordinate of first plot adapts gravity center of the inside polygon, therefor at least one symbol is plotted even smaller polygon. Symbol intervals are adjusted by the size of polygon area. Plotting rage is made little bit smaller than polygon area according to the symbol size, because of avoiding outer of symbol figure even origin coordinate is inside of polygon.

Fonts are outlined as polygons or lines, because of film printer dose not have same fonts with map data.

These processes for lines, polygons and fonts are able to mix and repeat to be adapted complex expression.

These generalized data are placed side by side according to opposite portrayal priority as paper map. This makes to opaque lower portrayal symbol at place of overlapped with others, when raster print data is created from symbolized data since raster data is overwrote on pre-processed raster.

7. Experimental test

Experimental test is done according to developed method, and the print data was made (Table-1).

Table-1 Specification of experimental test

Item	Contents	Remark
Map legend	1/25,000	
Area of test	Approx. 2.29 Km^2	Urban
Kind of map symbols	31	In test area
# of elements	150 lines, 189 polygons, 56 fonts	
Raster resolution	600 dpi	1597 X 2143 pix
Raster format	Index color TIFF	Approx. 3.42MB
Computer	Pentium2 450MHz, 384MB RAM	WindowsNT4.0

Existing map is digitized for an experimental test as figure-3. Figure-4 shows data that is adjusted as portrayal order after symbolizing of lines and polygons, and outlining of fonts. Figure-5 shows enlarged part of the figure-4. It is easy to understand lines and polygons compose these data, since rendering is released as figure-6. As the final result, figure-7 shows converted raster data for reproduction films production from generalized data (figure-4).

Processing times are shown on table-2. This means that working time is reduced to several hours from several days estimated on one sheet.

Table-2 Processing time

Item	Processing time
Symbolizing	2 second
Font outlining	1 second
Portrayal sorting	1 second
Raster conversion	19 second

8. Conclusion

Experimental raster data was compared with map image of 1/25,000 scale by GSI Japan(figure-8), and the portrayal qualities are estimated. At this time, figures of characters were out of estimation because of the same font was not able to adapted. Also colors were not estimation since colors are adjusted by volume of inks at printing.

These images proofed the system has ability to make print data for paper map at urban area except higher building along the urban road. Urban roads overwrote on the building edges of roadsides. This is requiring replacement of building edges face to roads in advance.

There were only 31 kinds of map symbols on the test area. And it is not much difficult to symbolize even it is jammed urban area since most of map symbols are composed by artificial structures.

Experiment tests at suburb and mountain area, and making of acquirement guides are necessary after this.

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Figure-3 Map data

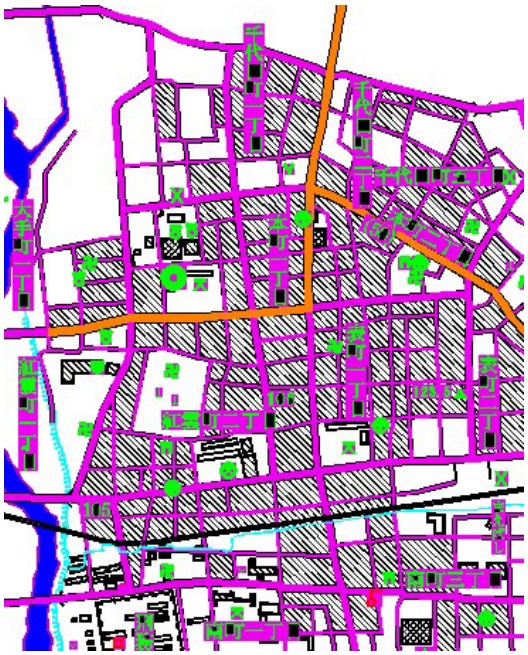

Figure-4 Symbolized data

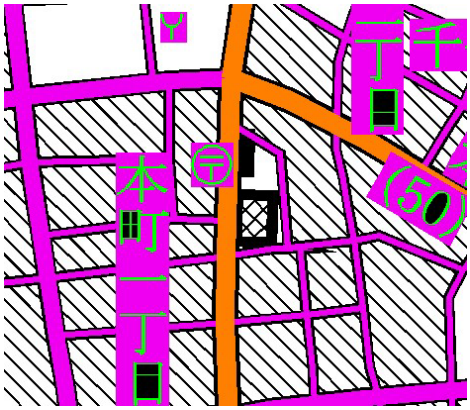

Figure-5 Symbolized data with rendering (Part)

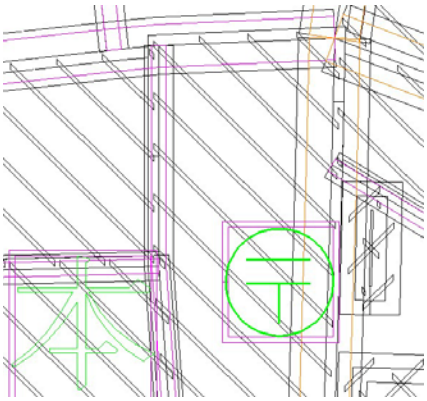

Figure-6 Symbolized data without rendering (Part)

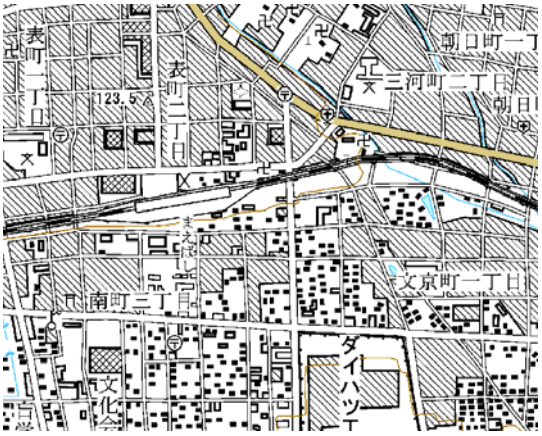

Figure-7 Generalized print data

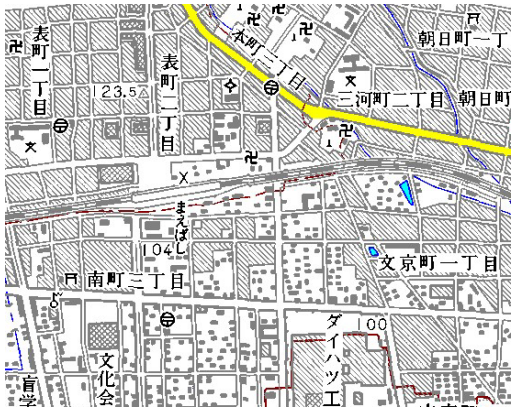

Figure-8 Map image by GSI Japan