Development of the GIS Educational Tools for Urban Planning
Substitution of the GIS educational environment using the GRASS

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1 Introduction

Sustainability is one of the most important issues in planning education. And it has been growing in various fields. To solve those complicated problems, GIS could be an indispensable tool. GIS manages huge urban spatial information efficiently, and is used not only in a urban planning field but in various research fields as a tool analyzed and visualized. Moreover, mobile communication devices, such as a mobile phone and PDA, have also spread widely in Japan, and GIS is used in the geographic information service (ex. search service of a restaurant or a nearest station, car navigation system, and so on.) On the other hand, there is a serious shortage of the GIS specialist in our country[1]. Therefore, the importance of GIS education is being discussed in various areas. In addition, it is regarded as questionable that high cost is also required for new introduction and annual maintenance of the commercial GIS application.

2 Purpose of this study

In this study, we challenge the development of GIS educational tools in the field of urban planning for undergraduate students in the university using the open source software which can generally be used by anyone. This paper is regarded as the introductory part towards the purpose achievement. First, we compare the functions of open source GIS software and commercial GIS software, and then verify the substitutability by using open source GIS software. In response to the result, we aim at clarifying validity, such as the improvement possibility of the cost reduction.

3 The situation surrounding GIS in Japan

First, we describe the application of the GIS and the spatial data which anyone can generally use, especially in the field of urban planning in Japan.

3.1 About the Source and Utilization of the Spatial Data

In the land, Infrastructure and Transportation Ministry of out country[1)], free service of browse of land information and GIS spatial data is offered through the Internet as part of the measure of spreading and promotion of GIS from April, 2001. The service currently offered is listed to below.

- Download Service of Digital National Land Information.
- Download Service of Block Position Reference Information.
- Land Information Web Mapping System (Experimental Stage).

The number of the data currently offered with “Download Service of Digital National Information” is 42 (as of December, 2003), and it is offered by vector, mesh, and the table data shown in Table1.

“Download Service of Block Position Reference Information” is the service which has the database for Geo-Coding and refers the latitude longitude information on a block level from the address. The conversion program and the maintenance tool are also usable with coordinates data. By using those data, the position information showned by latitude and longitude in a block level is added to the various statistics data containing address information. At the same time, it becomes possible to operate a display, analysis, and other functions on GIS.

Table 1: Classification of the Digital National Information

Format	Classification	Number	Major Example
Vector Data	Point	11	Habor, Land Price, Cultural Resource, Public Facilities, Power Plants
	Line	4	Coastal Area Line, Road, Railroad
	Surface	11	Urban Planning Area, Natural Park, Coastline
Mesh Data	2-D Mesh	1	Direction of Sea Wave, Sea Fog, Natural Fishing Ground
	3-D Mesh	8	Commercial Statistics 3-D Mesh, Industrlial Statistics Mesh
	1/2-D Mesh	1	Commercial Statistics 4-D Mesh
	1/10-D Mesh	3	Land Use Mesh, Lake Mesh
	Othre	1	Natural Landscape Mesh
			Height Above Sea Lebel Mesh
			Valley Density Mesh
Table Data		2	Tidal Wave/ Tsunami Table, River/ Water System Table

In addition, the “aerial photograph browsing system[2)]” and “Digital map download service[3)]” by the Geographical Survey Institute is maintained as a part of public information service. Especially, in “Digital map download service”, two vector-map data of different scale (1/2,500 and 1/25,000) are offered through the Internet. These data can be used as a base-map at the time of using GIS.

3.2 GIS Environment and in the Educational Institute

About the use of GRASS in the educational institutions in our country, there are several applied research examples in geography, and agriculture field, etc. However, there is still no positive research example using GRASS-GIS in the urban planning field which is our specialty. It is thought that the urban planning field which refers to environment information, such as a map and statistics, is one of the suitable research fields for introduction of open source GIS software in many cases.

3.2.1 About GIS Encironmental Meintinance

Department of Architecture and Environmental Systems, Shibaura Institute of Technology has two GIS training programs for undergraduate students using ArcGIS 8.2[4)] and MicroStation/Geographicss[5)]. And their initial introduction cost is approximately 40,000 USD, and we need about 33,000 USD/year for annual maintenance management cost (The number of licenses of ArcGIS are 100, MicroStation are 200). When these GIS application are replaced with the open source software, we could save those costs and use those money to buy spatial data and educational facilities in university.

3.2.2 Case Study of GIS Training Cource

Figure1 shows the situation of a computer terminal room. In this room, 96 sets of terminals are installed and it is always wide opened except for school hours. As shown in Figure 2 at the time of an exercise, the instructor’s computer screen is reflected in the monitor only for references installed in the center of each work station. A student works referring to this monitor if needed.

Figure 1: Practical Room

Figure 2: Individual Work Area

Here, we explain about an outline of the content of GIS training course in our department below.

3.2.3 Program1: Practice of Regional Environment Data Processing (For 3rd grade)

This training course aims at utilizing GIS for various local environment information, and learning the fundamental skill of processing, management and visualization technology of data.

The main contents of training are listed below.

- Attribute data (Kobe earthquake disaster data) massage and analysis using spread sheet.
- The method of construction and management of an attribute information database. Retrieval of attribute using SQL. Training of the attachment procedure which figure data and attribute data using *MicroStation Geographics*.
- Grasp of the disaster situation which combined two or more indices and creation of the urban area diagnostic chart.

3.2.4 Program2: Information Processing for Geo-Spatial Analysis (For 3rd grade)

This training course aims at acquisition of the programming technology and applied operation for GIS which is needed for the analysis of space information and figure data automatic drawing. This program is positioned as application of the example mentioned above.

The main contents of training are listed below.

- Information Processing for Geo-Spatial Analysis using *ArcGIS* Processing of basic attribute data, the readout of analysis results, acquisition of the statistics analysis technique.
- Acquisition of the automatic drawing programming technique of digital map (Vector Format). Record and reproduction of the operation using macro program.
- Information Processing for Geo-Spatial Analysis with DBMS.

4 Reproduction of the same contents by GRASS–GIS

In this section, we introduce an example which reproduced the same contents under the GRASS environment about the contents trained so far using commercial GIS software. In this paper, we used the GRASS package[6)] corresponding to internationalization for handling Japanese language in software.

4.1 Vector and Raster map data Overlay

Figure 3 shows the screenshot of map overlay training using two different format data (Vector map and Raster map) using *MicroStation GeoGraphics*. As shown in Figure 4, it checked that it was possible to reproduce the same work satisfactory under the GRASS environment. GRASS has the feature that the high compatibility between various format data. Moreover, it has the well-developed import and export functions.

Figure 3: work on the *MicroStation GeoGraphics*

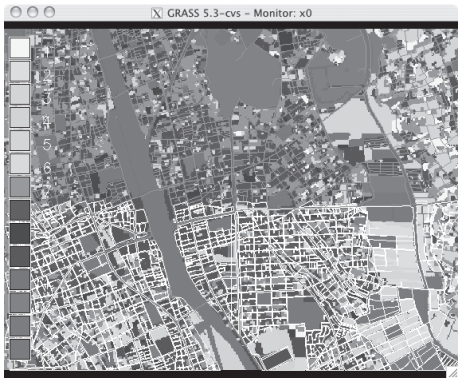

Figure 4: Work on the *GRASS*

We converted to the ASCII format from digital data, such as a digital map and land use mesh map, then, adopted approach to convert into binary format from ASCII format with a exclusive import command.

4.2 Construction and Management of Attribute Data and Data Analysis

Next, Figure 5 shows the screenshot of data search and classifying training using attribute database. Attribute data is stored in DBMS (*Microsoft Access2003*[7]) using the data of the disaster results of an investigation of the Kobe Earthquake in Japan in 1995.

As shown in Figure 6, it checked that it was possible to reproduce the same work satisfactory under the GRASS environment.

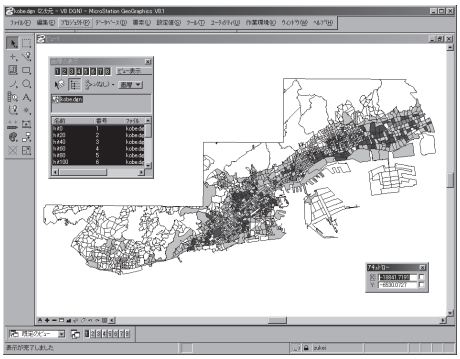

Figure 5: work on the *MicroStation GeoGraphics*

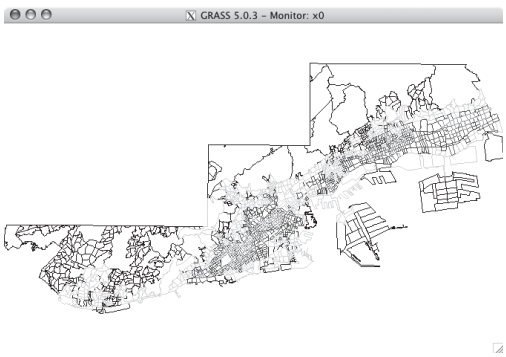

Figure 6: Work on the *GRASS*

GRASS managed various kinds files by the tree structure called “GRASS database”. In this management structure, figure data connect with attribute data by unique ID. Herewith, it is possible to extract the data classified regardless of the map file format such as vector or raster. Moreover, it is also possible to stock attribute data in an external database (*PostgreSQL*[8]) and to perform powerful attribute reference.

4.3 Geo-Spatial Analysis using Buffering Function, etc..

Next, Figure 7 shows the screenshot of data analysis training such as calculation of buffering centering on a station point data.

As shown in Figure 8, it checked that it was possible to reproduce the same work satisfactory under the GRASS environment. GRASS is equipped with the analysis function of the substantial geographical phenomenon. It is possible to excute easily buffering on the raster data treated here and combining and caluculation of each layer.

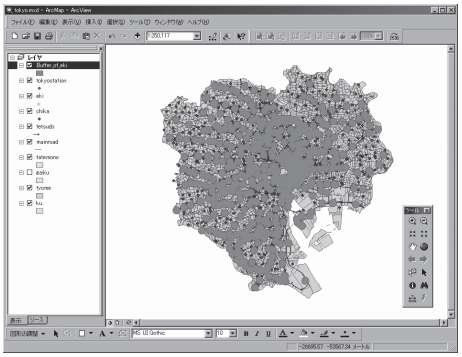

Figure 7: work on the *MicroStation GeoGraphics*

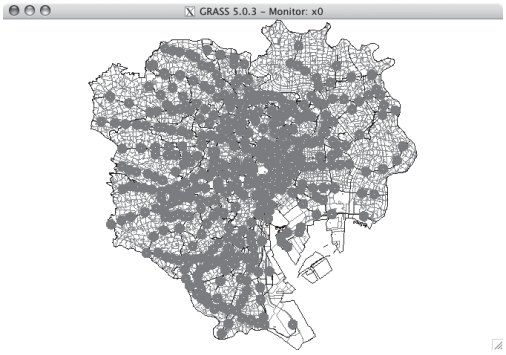

Figure 8: Work on the *GRASS*

4.4 Substitutability by GRASS-GIS

As having explained using the example previously, we confirmed that GRASS was equipped with sufficient function required as GIS software and showed that it was possible to reproduce the process and result of work satisfactory about the contents of training currently treated by the exercise as explained in this paper. Here, the GRASS-GIS's function and operationality are summarized into the following table2 through comparison with the general commercial GIS software's function and the feature. When it compares about commercial GIS and GRASS-GIS paying attention to a functional side, we can safely say that there is no difference point. When it is assumed that GIS training for the student in a university is performed, it is thought possible to replace all contents of training by open source GIS software.

Next, it observes about the operationality which was based on the user-interface or general accessibleness. GRASS is originally designed as software used by the command operation on the console screen under the UNIX CUI environment. Therefore, as compared with the general commercial GIS designed on the assumption that the use under the Windows GUI environment, a beginner like a student will feel the difficulty of getting used of the operationality and interface. Moreover, The function of comprehensive presentation to add the legend, orientation and scale, etc to the analysis results such as raster map data or graph data is one of the characteristic of the Commercial GIS's strong function. It may be difficult to cover all the same function only under the GRASS environment.

Table 2: Comparison of Functionality and Operatinality

Function and Operate in Commcial GIS Soxsftware	**Replacement by GRASS-GIS**
Various Data Input / Output, Data Convert	+++
Display of Legend Symbol, Create Histgram	++
Vector Map Data Handling	++
Raster Map Data Handling and Calculation	+++
Linkages between Figure and Attribute Data	+++
Data Analysis Functions	+++
Affinity with User Interface, Operationality	+
Presentation Functions	+

+++:Sufficient, ++:Possible, +:Bit difficult

5 Conclusion

In this paper, we have verified the substitutability by open source software on the basis of a comparison commercial GIS and GRASS-GIS paying attention to a functional side. Judging from the results so far obtained, it is thought that the substitutability by GRASS-GIS is very high. It is because there is almost no difference among both software and it can reproduce by the operation on GRASS about the contents of training. However, in the command operation base and GUI environment by the Tcl/Tk, software operation is difficult for a beginner.

It is thought that the operation and the description about usage of software and GIS. using expansion tools by the cooperation with Web can be supported to some extent these problems. Now, we are under development e-Learning System on Web combine with Mapserver as shown in a below figure9 and 10. In this system, the various geo-spatial data which the public organization of our country

distributed as in Table 1 is used as attribute data in GIS. By using this system, student can study the basis of GIS such as various data overlay, color-coding on map, etc easily on the Web.

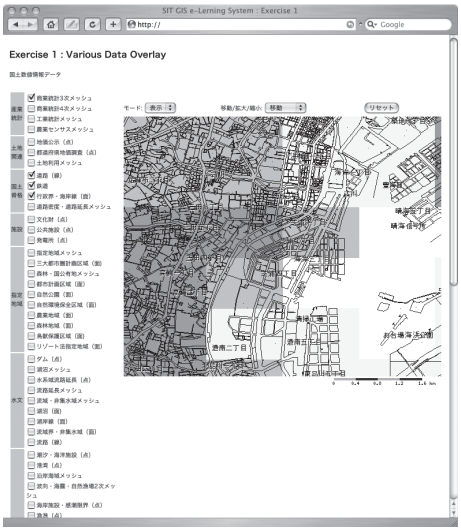

Figure 9: GIS e-Lerning System (Ex1. Various Data Overlay)

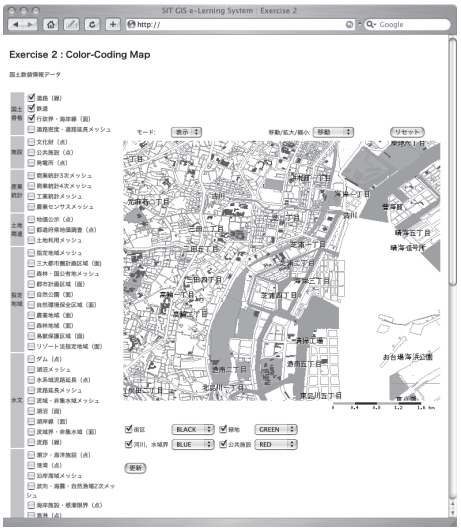

Figure 10: GIS e-Lerning System2 (Ex2. Color-coding Map)

As mentioned above, it is thought that the substitutability with the existing commercial GIS environment by the open source GIS is generally very high. After this, we'll challenge development of the teaching materials and the educational tool for study applicable to an urban planning field using GRASS-GIS.

Notes

[1)] `http://nlftp.mlit.go.jp/kj/`
[2)] `http://mapbrowse.gsi.go.jp/airphoto/indexmap_japan.html`
[3)] `http://sdf.gsi.go.jp/index.html`
[4)] ESRI Japan Corporation (`http://www.esrij.com`)
[5)] Bentley Systems, Inc. (`http://www.bentley.co.jp`)
[6)] Orkney, Inc (`http://www.orkney.co.jp`)
[7)] Microsoft Corporation (`http://www.microsoft.com/japan/`)
[8)] `http://www.postgresql.org/`

References

[1] Okunuki, K., et al., *Current issues in the use of GIS in Japanese K–12 schools*, Papers and Proceedings of the Geographic Information Systems Association, pages 271–274. GISA 2003.

[2] Helena Mitasova and Markus Neteler, *A Geographics Resources Analysis SUpport System Free General–purpose GIS*, pages 40–43. GIM International, 2003

[3] Markus Netteler and Helena Mitasova, *OPEN SOURCE GIS*: *A GRASS GIS Approach*, KAP, 2002