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GIS FOR THE EVALUATION OF ROAD TRAFFIC NOISE AT AREAS FACING ROADS IN JAPAN –KEY FUNCTIONS INCLUDING ESTIMATION OF THE NUMBERS OF RESIDENTS IN BUILDINGS–

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Abstract

GIS is an effective tool to accumulate various kinds of numerical maps and the attribute data relating to road traffic noise and to analyze the correlations between the data. In addition, combining prediction method of the road traffic noise with the benefits of GIS allows us to evaluate the noise field, from the past to the future, at areas facing roads concerned. Since propagation of road traffic noise is remarkably affected by buildings or other obstacles along the roads, their physical properties such as the locations and the heights should be carefully taken into account to calculate the road traffic noise. For evaluation of noise exposure by road traffic, it is important to distinguish between residential and non-residential buildings along the roads and then estimate the number of residents in each building. However, reasonable method to assign the population to the residential buildings, especially to the condominiums, is still a problem to be solved, because of limitations of information involved in the relating databases. The authors have shown a basic idea for calculating the number of people in the residential buildings and have been developing the method, in which the building maps and the population by the national census are used on GIS. In this paper, we discuss some key functions on the GIS application, including assignment of the residents, which are essential to be widely used for management and assessment of the road traffic noise.

1. INTRODUCTION

There are still a lot of complaints against environmental noises in Japan. This tendency is the same as the cities in many countries around the world. It is because many institutions have been concentrated in the cities, and such situations have made the noise fields complicated. Consequently, it brings extreme difficulties to provide appropriate measures for the noise reduction. We have to improve such conditions as far as possible, under keeping balance

between environmental preservation and convenience of our daily life. Road traffic noise is generally predominant among the environmental noises in cities. Therefore, in order to reduce the environmental noises properly, it is necessary to understand exactly current conditions of the road traffic noise.

Ministry of the Environment, Government of Japan has revised "Environmental Quality Standards for Noise" [1] and has enforced it in 1999. According to the new Standards, the road traffic noise shall be evaluated by L_{Aeq} instead of L_{A50}, at the both areas of 50m depths along the road, from obtaining the number and the ratio of buildings at which the noise levels exceed the standards that are individually determined by characteristics of the areas facing roads ("spatial assessment of road traffic noise"). Calculation of the road traffic noise for the spatial assessment has been permitted instead of actual noise measurements. Utilization of GIS has also been recommended as a tool for supporting the spatial assessment of road traffic noise. Now the local public bodies have been gradually introducing the GIS in this way.

Fujimoto *et al.* [2] have reported the achievement of the spatial assessment and the results using the GIS tool that was developed by a local public body in Japan, and the authors [3] have shown specification of road traffic census and have discussed application of the databases to prediction model of the road traffic noise, ASJ RTN-Model 2003 [4].

In this paper, we discuss some key functions or tools on GIS and especially focus on the method for the assignment of population to the residential buildings, for the purpose of wider application of GIS to management and evaluation of road traffic noise.

2. KEY FUNCTIONS ON GIS FOR MANAGEMENT AND EVALUATION OF ROAD TRAFFIC NOISE

GIS is an effective tool to accumulate various kinds of numerical maps and attribute data relating to the road traffic noise and to present the results after processing the data or making cross-analyses between the data. These functions may enable us to reconsider trends or changes of the noise field concerned from various viewpoints, if the maps and the data relating to road traffic noise can be arranged from the past to the present. With regard to the future noise condition, combining appropriate prediction method of the road traffic noise with the GIS provides useful information for the people living in the area and/or the local public bodies. Followings are some representative functions, which are essential to be widely used for management and assessment/evaluation of the road traffic noise.

2.1 Function for constructing databases from observations of road traffic noises

Local public bodies in Japan have been continuously observing road traffic noises at some fixed points for the purpose of monitoring the noise conditions in the governing areas. It is highly expected from the viewpoint of noise management and control to use them for analyses of the trend or change of the noise fields in the areas from the past up to present. For such analyses, not only the noise data but also the maps of building, land use, city planning and so on of these days are essential at least.

Minimum requirement for the function on GIS is an easiness to construct databases of the noise measurements, and the parameters that indicate the measurement conditions should be included in the databases. Traffic flow of the road concerned, meteorological conditions during the noise measurements and photographs around the measuring points are typical examples of the important parameters. **Figure 1** shows a concept for constructing the databases relating to the observation of road traffic noise on GIS and a view of the GIS extension developed to manage the databases.

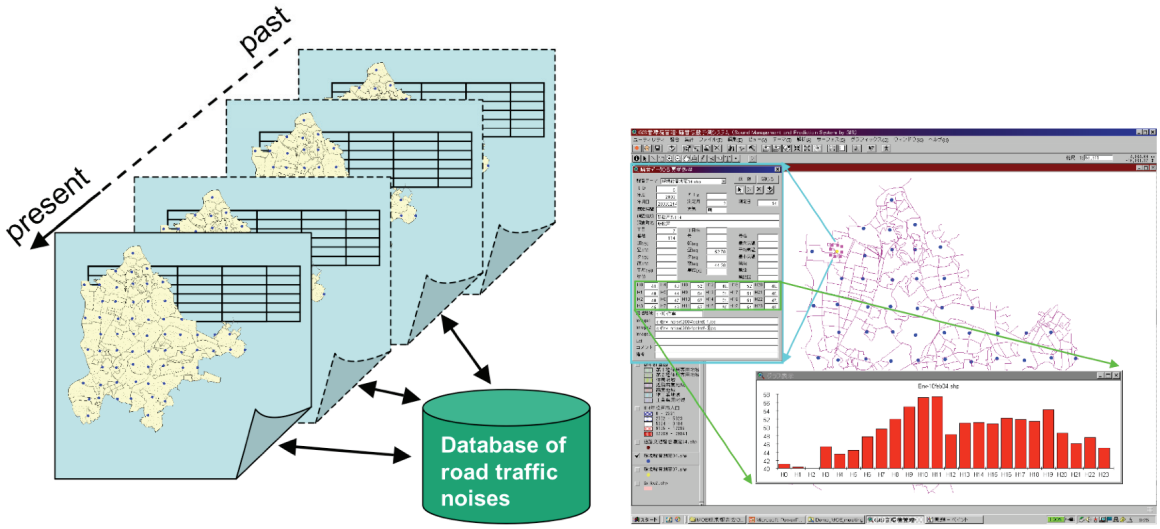

Figure 1. Schematic illustration of accumulating various data relating to road traffic noises (left) and a view of the GIS extension (right).

2.2 Function for noise abatement planning of road traffic noise

When noise abatement measures of the present road traffic noise are needed, the number of population who is exposed to excess noise in the area concerned is one of the important items taken into account. Though the database for population distribution is indispensable, it must be estimated in most cases. Depending remarkably on specification of relating databases and numerical maps, estimated results of the population distribution may range from the number of population per each administrative division to that per each household in each residential building.

In addition to noise exposure of population, we may have to consider many other items such as the kind and effectiveness of measures, position where the measures can be installed and so on, in the process of more concrete planning for the noise abatement. Moreover, cost of the measures adopted is very important factor. Since combination of these items is often very huge and the decision-making is generally difficult, technique to select the optimum combination and the evaluation method is remarkably desired [5]. Such a function on GIS may enable us to examine some proposals objectively in line with scenarios for the noise reduction measures.

3. ASSIGNMENT OF POPULATION TO THE RESIDENTIAL BUILDINGS

As described above, the assignment of population to the residential buildings remarkably depends on specification of the relating databases available. The necessary databases are basically both the number of population and the numerical map of buildings in the area concerned.

The simplest way to assign the residents to the buildings is to distribute all the residents equally to all the buildings. However, in order to make the assignment more realistically, another proper way is essential. For example, first we distinguish between the residential and non-residential buildings, next calculate the number of households in the residential buildings, and lastly assign all the residents in the area equally to all the households. This procedure allows us to estimate the number of residents on each floor in the residential buildings and provides the detailed population distribution in the area under consideration. The authors have

adopted the latter method and have developed the function extension on GIS.

3.1 Basic data

We also apply the type of land use defined by City Planning Law, in addition to two kinds of databases described above. The data includes representative land use of each area from the administrative point of view, and it is typically classified into dwellings, commerce, industries and so on. The land use data are digitized and are converted to the numerical map, which can be handled on GIS, if they are not available in the digital format. Data of a national census is used to develop the numerical map of population distribution, while the building map is purchased on the market.

3.2 Calculation procedures

Figure 2 shows calculation procedures for the assignment of population to the residential buildings. The outline is as follows:

- Addition of the land use categories to the building polygons (Step-1).
- Addition of the number of rooms on each floor to the building polygons, especially for the multi-story buildings, referring supplementary information including the building map (Step-2). This is an input file to the process for distinction between residential and non-residential buildings.
- Estimation of residential buildings by analyzing the nameplates. For the multi-story buildings, whether each room is for residential or not is determined (Step-3).
- Assignment of population to the residential buildings found in the Step-3 (Step-4).

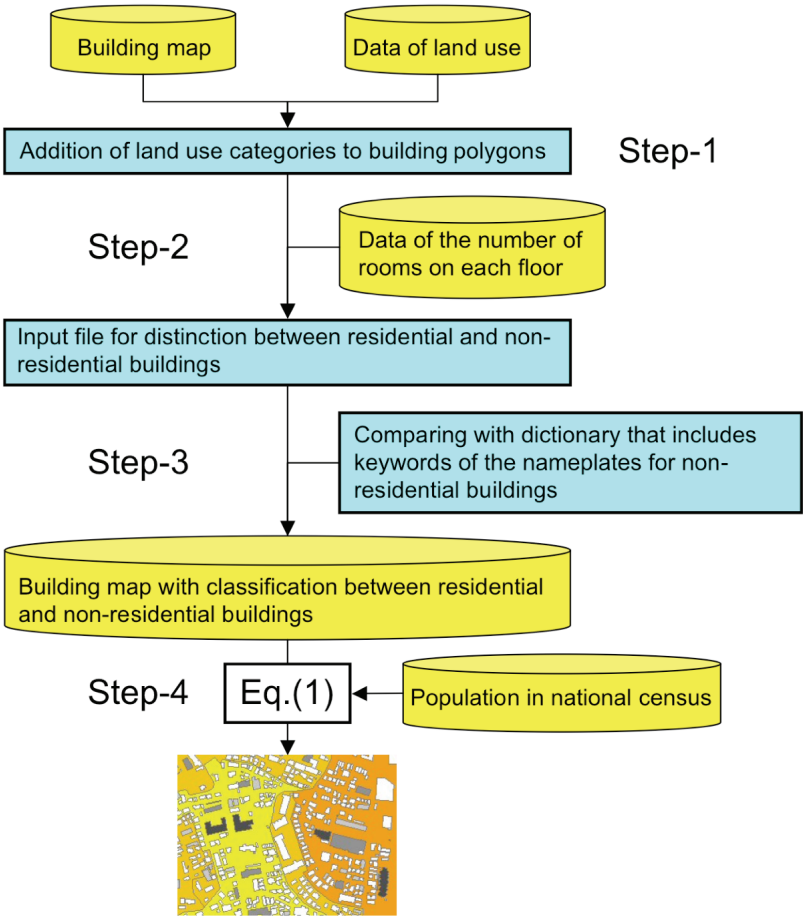

Figure 2. Calculation procedures for the assignment of population to the residential buildings.

In the Step-3, we focus on the nameplates of each building (detached house) or each room in multi-story residential buildings. Before distinction of the buildings, we have prepared a dictionary including keywords (character strings) of typical nameplates for non-residential buildings. Namely, this dictionary is referred to determine whether the building concerned is classified into non-residential one or not, based on analysis of the nameplate. For example, the nameplates of buildings having a term "Co., Ltd." can be estimated mostly as non-residential ones.

An example of the dictionary is shown in **Table 1**. It consists of various likely keywords in nameplate. In the process of making the distinction, some corrections of the keywords in the dictionary have to be performed, since even the dictionary can't analyze all the characters included the nameplates. This operation is to add proper keywords to the dictionary successively, and repeats several times to analyze all the nameplates of the buildings appropriately. As a result, a household is assigned to each building or to each room in the multi-story residential buildings.

Table 1. Keywords in the dictionary used for analysis of building's nameplate.

Keywords		
学院	倶楽部	サロン
教室	事務所	フォト
ゼミ	工業所	不動産
*校	作業所	美容室
*塾	作業場	お好焼
リゾート	出張所	化粧品
ホテル	音楽院	理容店
イン	製作所	ピアノ
旅館	フロア	カフェ
旅荘	サロン	リース
ミュージックセンター	デンキ	酒店
エンタープライズ	プラザ	工芸
エンジニアリング	工芸社	内装
コーポレーション	営業所	売店
(株)	バラ園	塗料
(株)	販売所	電器
(株)	給油所	電機
(事)	自動車センター	通信
(事)	中古車センター	電設
(事)	工場	百貨
(財)	ソリューション	商会

In the processes until the Step-3, the number of households in the area concerned can be obtained. Therefore, the average population per a household is calculated by the following equation (1) in the Step-4.

$$\frac{\text{Total population living in the area}}{\text{Total number of households in the area}} \tag{1}$$

The procedure enables us to assign the average population per a household to a residential building (detached house) or residential rooms in multi-story buildings, and total resident population in the multi-story building can be calculated by multiplying the number of households by the average population per a household. **Table 2** shows an example of the database of building map added the number of population every floor.

Figure 3 is a case study for the assignment of population. This is the area mainly for dwelling, and about 3,700 of population is living in about 900 of the buildings (The number of rooms concerned is about 1,750). For the distinction of the buildings, 551 of the keywords were necessary in the dictionary. The calculation time for all procedures took around two

minutes.

Table 2. Database of building map added the number of population every floor.

HOUSENAME	MAP_ID	AREA	# Population	# Houseold	FLD1	FLD2	FLD3	FLD4	FLD5
かねたや家具八柱センター	2640604	394.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0
石崎哲雄	2640604	131.10	1.9	1.0	1.0	1.0	0.0	0.0	0.0
ファミリーマートたかはし桜通り店	2640604	173.85	0.0	0.0	0.0	0.0	0.0	0.0	0.0
チェリーアベニュー	2640604	117.48	1.9	1.0	1.0	1.0	0.0	0.0	0.0
SUEHIRO	2640604	270.80	28.9	15.0	9.6	9.6	9.6	0.0	0.0
肉タムラ	2640604	55.28	1.9	1.0	1.0	1.0	0.0	0.0	0.0
クリスタルスポーツクラブ八柱	2640604	770.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
高橋忠男	2640604	132.96	1.9	1.0	1.0	1.0	0.0	0.0	0.0
	2640604	13.35	0.0	0.0	0.0	0.0	0.0	0.0	0.0
柏葉台ハイツ	2640604	587.45	59.7	31.0	11.6	13.5	11.6	11.6	11.6
ニューマリッチSK	2640604	117.36	5.8	3.0	1.9	1.9	1.9	0.0	0.0
でんきのホットインやばしら店	2640604	78.61	0.0	0.0	0.0	0.0	0.0	0.0	0.0

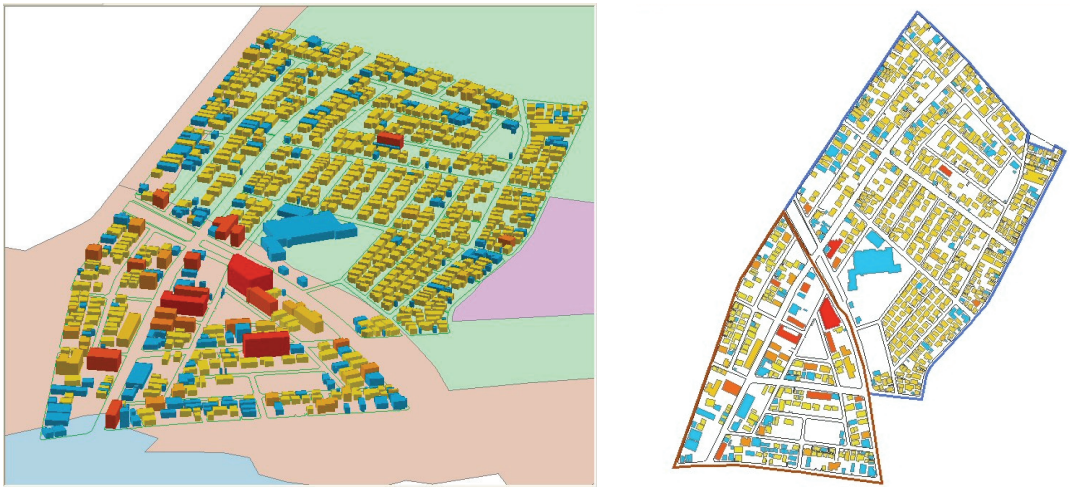

Figure 3. 3D visualization of population distribution (left) and the number of residents on second floor in each building (right). Blue objects indicate non-residential buildings.

Left figure of **Figure 3** shows a 3D view of the number of population in each building in the area. As indicated in the middle of the figure, the residents don't assign to the building even though it is a multi-story building with larger building area. It means that the method proposed in this paper, applying the nameplate of each building to distinguish between residential and non-residential ones, is useful.

Right figure of **Figure 3** is a 2D presentation of the number of residents on the second floor in each building. The population distribution on arbitrary floor can be found as indicated in **Table 2**, since the resident population on each floor in each building can be calculated by the method. Thus, we might expect more precise evaluation of the noise exposure by means of combining the calculation method of the population assignment with noise map of road traffic at arbitrary height (at the height of arbitrary floor).

4. SUMMARY

For the purpose of wider application of GIS to management and evaluation of road traffic noise, key functions on GIS and brief outline of the method for the assignment of population to residential buildings are shown.

Since the results obtained from the functions on GIS depend remarkably on the relevant

databases, preparation or arrangement of the databases is the most important. For the assignment of population, the nameplate is the key information, and, therefore, the improvement of the dictionary for analyses of the nameplates is a significant subject. Moreover, maintenance or update of the related databases should be continued to reflect current conditions of the road traffic noise.

ACKNOWLEDGEMENT

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