A Study on Analysis of an Urban Spatial structure, based on the GIS Technique

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목 차

Abstract

This paper is an analysis of the Category Individual Residence urban spatial structure along the National Route 20 (Koushu-Kaido), one of the major roads in Japan, and the degree of differences between locations and its changes between the points of time. The analysis was based on the GIS technique. Whilst, previous studies were based on municipal boundaries or mesh units as sources of data, GIS allowed the use of variable geographical units, Roadside zone, Inner zone, North zone, South zone, Blocks. As an example to apply the technology of GIS, 1986's and 1991's building polygon data of the Urban Planning Bureau of Tokyo Metropolitan Government are used. The layers referred to the analyses is the building polygons with the amount of stories, building area, floor area and the material of the building. Two statistical analysis are executed; one is the test of the regional equality about the number of story of building, building area, floor area and fireproof building ratio.

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Ⅰ. Introduction

There are the zone contiguous to a main road (so-called "Gawa") and the zone not to one (so-called "An") in big cities of Japan, especially in Tokyo Metropolitan Wards. In Japanese large cities, we have the characteristic structure of urbanized area, the compound of so-called "Gawa" and "An". "Gawa" is the zone contiguous to a main road while "An" is the zone not contiguous to one. Especially in of Tokyo metropolitan area, we find the typical "Gawa" / "An" 1)compound structures along most main roads.

The purpose of this study is to corroborate the urban pattern's characteristics of metropolitan area along the main road; above "Gawa" / "An" contrast and other structures such as north side / south side of the road and the distance from the central area. Moreover the change of those structures between two points of time are explored and the factors which effects the pattern and the change are inferred.

We executed the analysis by using GIS on the work station and the personal computer.

Ⅱ. Process of the analysis

1. The data source and the tools

For the analysis, we use GIS data of building polygons in Tokyo 23 Wards Area produced by the Urban Planning Bureau of Tokyo Metropolitan Government. They are embedded in one of the layers composing the Urban Planning Map Information System of the Bureau in 1986 and in 1991.

The tools for analysis are ARCINFO on Unix workstation and MAPINFO on Windows PC. We used the two applications cooperatively.

2. Study area and the concepts for creating divisions

The National Route 20 (generally called "Koshu Kaido") is the object of the study. We selected its segment between Uchibori Street in central Tokyo and the boundary of Tokyo 23 wards, and made the buffer zones and the divisions for comparative analysis by the following procedure.

1) Creating the buffer zones

The buffer zones were created the process as follows, that is to say,

① Selecting the involving road polygons of the Route 20 from the original data (the polygons are divided by the unit base map area),

② Merging the road polygons into one feature,

③ Buffering by 30 meters around the

merged polygon and creating the road side zone,

④ Creating a new line by 45 meters around the merged polygon for another buffer ,

⑤ Buffering by 30 meters around the new line and creating the inner zone.

After that, the road side zone and the inner zone along the road were created.

2) Creating direction divisions

The Route 20 runs from the east to the west. So we can recognize 2 directions of it, i.e., north side and south side. By the direction, the road side zone and the inner zone were divided.

3) Creating block divisions

The 4 blocks, sequentially A,B,C,D, were created by the distance from the central Tokyo area to the boundary of Tokyo 23 Wards. They are divided by Yamate Avenue, Ring Route 7 and Ring Route 8. The number on the map indicates the unit base map number.

Now in total, we created 16 divisions (2 kinds of zones × 2 directions of the road × 4 blocks) of the object area. The building polygons inside each division were selected. The examples of the selected polygons are shown in Fig.1.

Tab.1. number of buildings in Tokyo

1986

Number of Stories (F)	INNER NORTH	ROAD NORTH	ROAD SOUTH	INNER SOUTH	AVERAGE
A Block	2.078	2.051	2.031	1.984	2.036
B Block	2.082	2.222	1.842	2.026	2.043
C Block	1.849	1.715	1.773	1.817	1.789
D Block	1.847	1.769	1.760	1.832	1.802
AVERAGE	1.964	1.940	1.852	1.915	1.917
Building Area	INNER NORTH	ROAD NORTH	ROAD SOUTH	INNER SOUTH	AVERAGE
A Block	57.890	65.864	52.585	54.157	57.624
B Block	72.082	62.008	79.140	61.409	68.660
C Block	63.045	76.696	75.674	71.814	71.807
D Block	70.718	71.514	72.165	74.671	72.267
AVERAGE	65.934	69.020	69.891	65.513	67.589
Floor Area	INNER NORTH	ROAD NORTH	ROAD SOUTH	INNER SOUTH	AVERAGE
A Block	119.674	134.353	108.265	111.108	118.350
B Block	160.073	146.342	144.387	124.890	143.923
C Block	113.112	130.322	135.107	129.509	127.013
D Block	130.104	129.538	131.127	133.855	131.156
AVERAGE	130.741	135.139	129.722	124.840	130.110
Fireproof Building Ratio	INNER NORTH	ROAD NORTH	ROAD SOUTH	INNER SOUTH	AVERAGE
A Block	0.111	0.179	0.156	0.116	0.141
B Block	0.137	0.238	0.105	0.141	0.155
C Block	0.043	0.097	0.135	0.083	0.089
D Block	0.058	0.108	0.100	0.065	0.083
AVERAGE	0.087	0.156	0.124	0.101	0.117

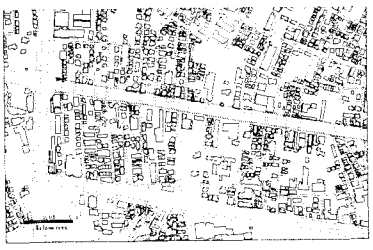

Fig.1. The examples of the selected polygons

3. Concept for comparative analysis

We explored the difference by the above divisions, the factors concerned with it and their changes. The attributes used as the indices of physical pattern are (1)number of stories,(2)building area,(3)floor area of each building and (4)fireproof building ratio of each division.

For the purpose, we executed the test of equality of two means between contiguous divisions about each attribute and the analysis of variance considering the concepts of divisions as the factors of influence.

Tab.1 shows the examples of the attribute spreadsheet (number of stories). Each attribute of each building in 16 divisions is arranged like the table.

Tab.2 Tables of the verification

1. NORTH SIDE
A,B,C,D BLOCK [NORTH[ROAD VS ROAD]]
A,B,C,D BLOCK [NORTH[ROAD VS INNER]]
A,B,C,D BLOCK [NORTH[ROAD[A VS B]]]
A,B,C,D BLOCK [NORTH[ROAD[B VS C]]]
A,B,C,D BLOCK [NORTH[ROAD[C VS D]]]
A,B,C,D BLOCK [NORTH[INNER[A VS B]]]
A,B,C,D BLOCK [NORTH[INNER[B VS C]]]
A,B,C,D BLOCK [NORTH[INNER[C VS D]]]
NORTH [ROAD[A + B + C +D]] VS INNER[A + B + C +D]]]

2. SOUTH SIDE
A,B,C,D BLOCK [SOUTH[INNER VS INNER]]
A,B,C,D BLOCK [SOUTH[ROAD VS INNER]]
A,B,C,D BLOCK [SOUTH[ROAD[A VS B]]]
A,B,C,D BLOCK [SOUTH[ROAD[B VS C]]]
A,B,C,D BLOCK [SOUTH[ROAD[C VS D]]]
A,B,C,D BLOCK [SOUTH[INNER[A VS B]]]
A,B,C,D BLOCK [SOUTH[INNER[B VS C]]]
A,B,C,D BLOCK [SOUTH[INNER[C VS D]]]
SOUTH[ROAD[A + B + C +D]] VS INNER[A + B + C +D]]]

3. COMPARISION WITH BLOCKS

A [NORTH[ROAD +INNER] + [SOUTH[ROAD +INNER]]] VS B [NORTH[ROAD +INNER] + [SOUTH[ROAD +INNER]]]

B [NORTH[ROAD +INNER] + [SOUTH[ROAD +INNER]]] VS C [NORTH[ROAD +INNER] + [SOUTH[ROAD +INNER]]]

C [NORTH[ROAD +INNER] + [SOUTH[ROAD +INNER]]] VS D [NORTH[ROAD +INNER] + [SOUTH[ROAD +INNER]]]

4. COMPARISION BETWEEN NORTH SIDE AND SOUTH SIDE

A,B,C,D BLOCK [NORTH[ROAD +INNER] VS SOUTH[ROAD +INNER]]

NORTH[ROAD[A + B + C + D] VS SOUTH[ROAD[A + B + C + D]]

NORTH[INNER[A + B + C + D] VS SOUTH[INNER[A + B + C + D]]

NORTH[A + B + C + D] VS SOUTH[A + B + C + D]

5. COMPARISION BETWEEN ROAD SIDE ZONE AND INNER ZONE

ROAD[A + B + C + D] VS INNER[A + B + C + D]

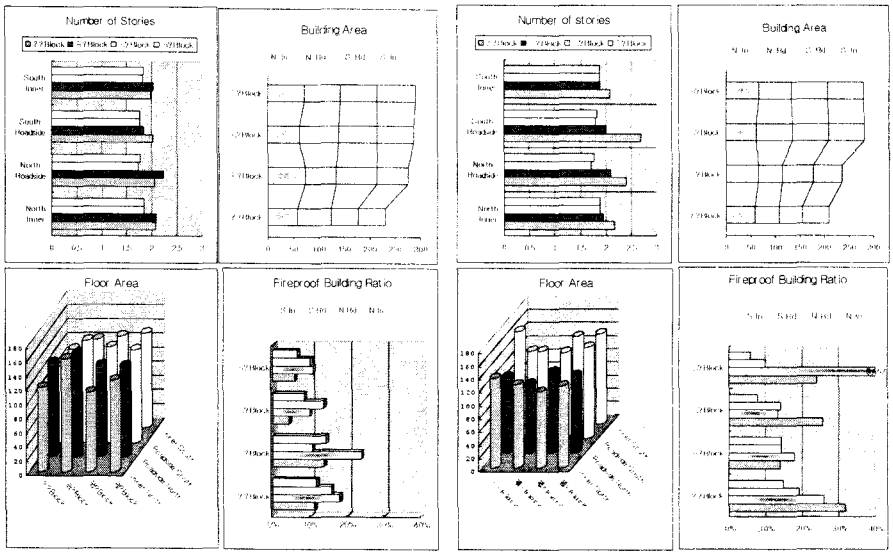

Fig.2. The means of the attributes in each division of 1986 and 1991

Ⅲ. Results

The results are presented in Fig.2.

Every mean value is calculated in the base of the number of buildings(Tab.2.).

In the tables, a black arrow means that the null hypothesis on equality of the two divisions is rejected with under 1% error level (that is to say, the significant difference can be detected), a gray one likewise with 1%-5% level and a white one means the null hypothesis is not rejected with 5% error level (namely, there is no significant difference).

A black arrow means that the difference between two divisions newly became significant in 1991, a horizontal hatching arrow means the significant level rose from 5% to 1% between two points of time, a vertical one means it fell from 1% to 5% and a white arrow means the difference became non significant. The division pairs with no arrow are the ones no change was detected.

Ⅳ. Results of Comparison of the Area Differences in the Attributes of Structural Attributes

With the tables and figures in chapter 3, we can summarize the findings as below.

Number of Stories

From 1986 to 1991, in the A block, there was a 0.1 story increase. In the south Roadside zone was an increase from 1.850 story to 2.076 story. In nearly all areas this increase was seen. This is due to the increase in both public and private development projects. Another distinct finding was that while in 1986, the difference in the building stories was found only along Ring 7 (between area B and C), in 1991 a difference was seen also along Yamate Avenue (between area A and B).

Building Area

Building area decreased in size from 1986 to 1991. This was evident in all areas surveyed. Results show that Category Individual Residence were displaced by Commercial Buildings to suburban areas. In 1986, there were significant differences in the building area between all areas on the horizontal axis (i.e. A, B, C, D blocks). However in 1991, the difference was seen only between area B and C.

Floor Area

In 1986 Northern Inner zone between all blocks (A to B, B to C, C to D), there were differences (error level 5%) but in 1991, there were almost no recognizable difference. The reverse was true of the South Zone (area 60 meters from the road) where, there was none in 1986 and there was difference in A and B block, B and C block.

Fireproof Building Ratio

From 1986 to 1991, areas excluding B, the Fireproof Building Ratio increased. In the A block, 14% to 23%, in the C block 8% to 15%, in the D block 8% to 26.4%. On the other hand, in the B block, which had the highest ratio in 1986, a decrease of 0.3% was seen in 1991. Of the 4 attributes that were under study, the Fireproof Building Ratio showed the greatest change from 1986 to 1991.

1. Summary of the findings and discussions

There was more category individual residence buildings on the Inner zone than Roadside zone. This trend was reverse of that seen in all buildings. In the area between Uchibori Avenue to Ring 8, there were more residential buildings on the north zone. From 1986 to 1991, the stories of the buildings and the Fireproof ratio increased, while Building Area and Floor Area decreased.

V. Conclusion and further problems

1. Technical Aspects of GIS

In this study, the data used are the individual building polygons and their attribute table. A 2.5 x 1.5Km map was used as one layer. As of now, there are no boundary lines drawn between the properties. Hence, property boundaries are indistinct and the ratio of buildings to land area is unavailable as data. To overcome this problem, Voronoi algorithm and Arc Macro Language program can be used to calculate the above data.

There have been no previous studies of the urban spatial structure based on the GIS technique, which compares different countries such as Japan and USA.

2. Subjects for Future Consideration

There are five matters to be studied further in the future.

1) Definition of the Road Side zone and the Inner zone

2) Study of other areas.

3) Study of Multi-tier constructions on streets of fairly narrow width such as alleys.

4) Study of other time periods.

5) Study of Urban area spatial structure in relation to the Urban planning laws

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