PRACTICAL APPLICATION OF DIGITAL MAPPING TECHNOLOGY

—CASE OF SPATIAL ANALYSIS BY 3D DIGITAL MAPPING—

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ABSTRACT

The biggest advantage of digital mapping technology is said to be the flexibility in the expression of maps such as the output at optional scale and of the optional items as well as the reproduction of maps. However, these are on the extension line of conventional analog mapping technology and do not point to the essence of digital mapping. The real worth of digital mapping can be said to be the utilization of digitalized 3 dimensional coordinates. So far, attempts have been made to use the 3 dimensional data obtained by digital mapping for the applications of each field, and in fact, they have been applied to the businesses in practice.

In this study, we discussed the method to extract the structures and topography which are protruding into the upper space which has to be reserved, and to identify the extent of protrusion and the locations of these objects. The digital mapping can be said, after all, to be the effective means to efficiently acquire the heights of scattering structures and topographies.

In this paper, we will introduce the process of current study using the analytical plotter, and then report the procedures by which we used the digital photogrammetry system in an attempt to solve the problems found out in the process of current study. We will discuss the efficient study methods and new possibilities obtained from these results.

1 OUTLINE OF THE STUDY

1.1 Study area

We selected a middle sized city of 40 k m² including the surrounding areas which has mountains of 200 ~ 300 m in height at its north east as the study area.

1.2 Objects of study

We assumed a virtual space above the study area and specified its lower limit surface. We formed the surface by combining a surface which has inclinations along with the ground surface and a horizontal surface. We specified as the study objects the tall building, towers and mountains having the value of Z coordinate which is higher than or close to the lower limit surface.

1.3 Details of study

We used monochrome aerial photograph of 1 / 20,000 for the measurement. We measured and calculated study objects having the highest altitude and the distance from the surface, and attempted to construct plans and longitudinal section maps to identify those locations.

2 STUDY METHOD USING THE ANALYTICAL PLOTTER

2.1 Measurement by analytical plotter (judgment whether the object is protruding over the lower limit surface)

It is necessary to acquire the accurate height of object protruding over the lower limit by the actual measurement at the side. However, it is difficult to presume at the site whether the object concerned may contact with the virtual surface.

Therefore, we made preliminary measurement using the analytical plotter in order to reduce the work load at the site.

1). We inputted the peak coordinates of each surface which composes of the lower limit surface into the analytical plotter.
2). We made an arrangement so that the judgment shall be made on real time as to whether the Z coordinate of a mess-mark is higher or lower than a point on a surface having the same X, Y coordinates.
3). We made an arrangement so that an alarm is issued and the plotting operator is prompted for the attention when the value of Z coordinate of mess-mark is larger than the point of the surface.
4). Then the plotting operator measured the topographies and ground objects which are close to or protruding over the surface within the plotting range.
5). The plotting of ground objects was also made at the same time.

2.2 Calculation by general purpose computer

The difference of altitude between topographies and ground objects this acquired and the surface was calculated accurately by a general purpose computer. We outputted the results as a list (Table 1) and carried it at the time of actual measurement at the site.

Table 1: Measurement values and calculation results

NO	Altitude of surface (A)	Altitude of ground	Height of protruding object	Altitude of protruding object (B)	(B)-(A)		X coordinates	Y coordinates
1	261.78	261.22	0.48	261.70	-0.08		-25570.500	-134374.063
2	262.13	260.93	0.77	261.70	-0.43		-25556.055	-134400.141
3	262.48	260.82	0.88	261.70	-0.78		-25541.016	-134424.914
4	262.84	260.56	1.14	261.70	-1.14		-25526.359	-134450.945
5	263.12	259.86	8.45	268.31	5.19	#	-25495.006	-134459.878
6	263.20	260.17	1.53	261.70	-1.50		-25511.355	-134477.070
7	263.56	259.14	3.01	262.15	-1.41		-25496.395	-134503.211
8	263.62	258.06	14.41	272.47	8.85	#	-25586.176	-134560.602
9	264.22	256.60	7.92	264.52	0.30	#	-25513.082	-134575.516
10	264.64	258.19	5.33	263.52	-1.12		-25451.680	-134581.445
11	266.30	256.24	16.02	272.26	5.96	#	-25297.063	-134651.531
12	266.97	255.16	13.45	268.61	1.64	#	-25396.098	-134773.336
13	266.98	253.09	15.41	268.50	1.52	#	-25285.637	-134710.148
14	267.45	251.30	21.42	272.72	5.27	#	-25318.037	-134774.648
15	267.73	250.30	16.71	267.01	-0.72		-25346.777	-134817.828
16	268.08	246.48	19.79	266.27	-1.81		-25303.623	-134826.894
17	268.79	249.23	14.94	264.17	-4.62		-25320.028	-134904.257
18	268.86	248.68	20.69	269.37			-25337.232	-134920.448
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# indicates those which is protruding over the surface

2.3 Precise investigation by site measurement

We actually measured the height of topographies and objects contained in the list and other objects which had been missed in the plotting works, and made investigation on the information of their name, owner, administrative unit, etc. We employed the measurement value of plotter for the height of trees, and acquired the actual height of structures from the design drawing if it was available.

2.4 Construction of maps

We calculated the height data accurately measured at the site as well as other information again by general purpose computer. The height was described on the maps for the topographies and objects protruding in a form of spot such buildings and high towers. Those which protruded on a form of space such as hills were expressed by placing hatching over them. In this study, we constructed plans at the scale of 1 / 10,000 and 1 / 20,000 as well as longitudinal section drawing which shows relative relation to the surface. These were developed by the ball point pen plotter. We traced them and plotted ground objects, and arranged it in a form of map.

3 PROBLEMATIC POINTS

The matters found out by this study as to need further improvement are the following 3 points.
1) Improvement of work efficiency to extract topographies and ground objects by analytical plotter
2) Reduction of time used for the construction of maps
3) Limitation of recognition by maps

3.1 Improvement of work efficiency to extract topographies and ground objects by analytical plotter

The operator of analytical plotter made plotting and measurement by a stereo model obtained from aerial photograph. Extraction was done by presuming the scope and height of surface only based on the alarm sound. As a result, there were some objects which were omitted in the course of extraction work, which were later found by site workers and from existing materials such as maps, and each time, it was necessary to repeat the measurement, calculation and site measurement using analytical plotter.

3.2 Reduction of time used for the construction of maps

We used long time for spatial treatment (patching up of screen tone) of sea surface and rivers. Also, far longer time than expected was necessary for the works to correct the shape of ground objects after the completion of spatial treatment.

3.3 Limitation of the recognition by maps

There was a limitation in grasping the three dimensional relation of position between topography / ground object and the surface only by the plans incorporating the heights and longitudinal section maps.

4 PROPOSAL OF PLAN TO IMPROVE BY DIGITAL PROCESSING

We attempted to solve the problems pointed out in the above by changing;
1) Measurement by analytical plotter, and
2) Construction of map by tracing
to
1) Measurement by digital photogrammetry system and
2) Output of maps from CAD.

5 CONCRETE METHOD OF EXPERIMENT

1) A stereo model is made by inputting the picture image obtained by scanning of aerial photograph into the digital photogrammetry system.
2)Each surface is developed as 3-dimensional polygon on the CAD of digital photogrammetry system.
3)While acquiring the normal 3 dimensional topographic data, a point is inputted to the highest position of the topographies and ground objects which are likely to contact the surface. Whether the object protrudes over the surface is judged by the operator from the positional relation with the surface already developed.
4) The topographies acquired are edited by CAD, and sea areas, etc. are outputted after converted into polygons and placing hatching on it.
5) The view from a side becomes the longitudinal section drawing in order to develop the topographies / ground objects and surface 3-demensionally using CAD.

6 RESULT AND DISCUSSION

6.1 Measurement of protruding ground objects

The effects confirmed in the measuring experiment of protruding objects are as follows:

1)It is possible to confirm the area of lower limit surface at a glance (Figure 1).
2) It is possible to determine whether the object is over or under the surface by rendering the surface from the upper viewpoint (Figure 2).

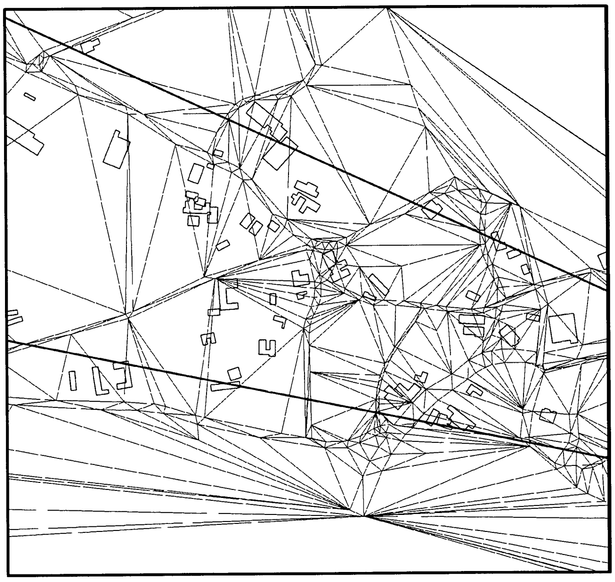


Figure 1 : Surface and topography

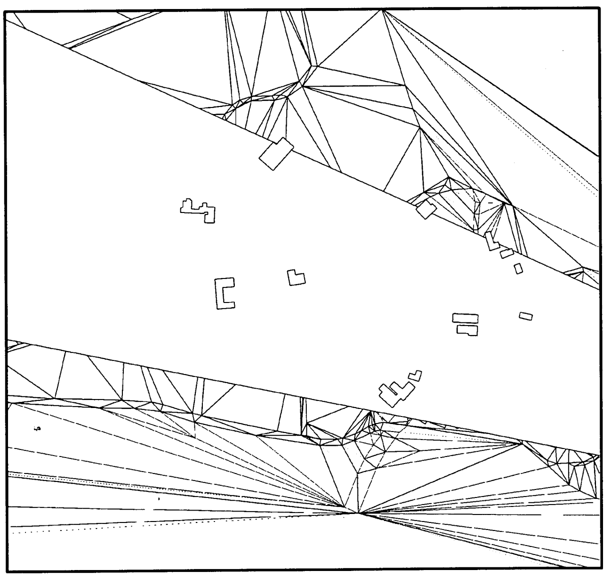
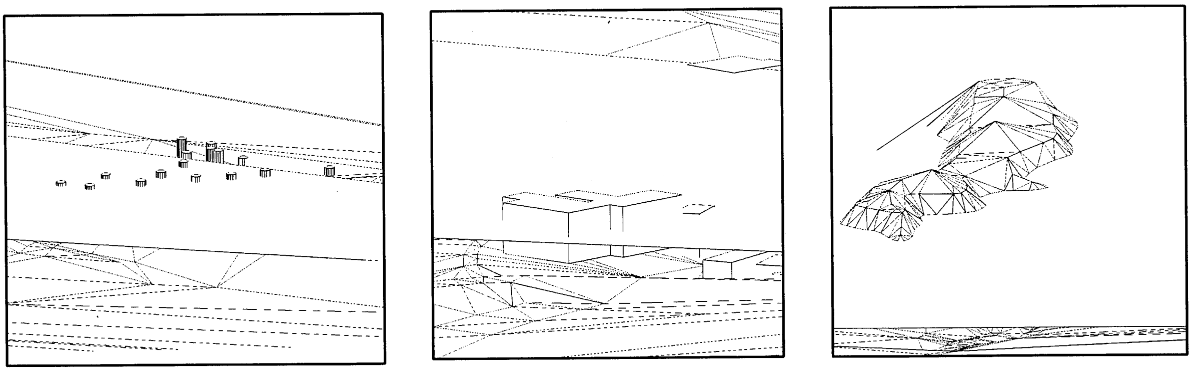


Figure 2 : Building protrusion of which is confirmed by rendering

3) It is easy to judge whether the object protrudes over the surface because the position of viewpoint can be changed optionally (Figure 3).



(a) (b) (c)

Figure 3 : Tower (a), building (b) and mountain (c) for which protrusion is confirmed

4) While the surface data are inputted as the test data of coordinate queue in the case of analytical plotter, the data are inputted in an interactive way, and as a result, the profile of surface can be instantly confirmed and input error is eliminated.

The improvement was the result that the function of digital photogrammetry system was used as CAD.
In the case of analytical plotted specialized in data input, the viewpoint is limited to upper position as a matter of course. Although there are many plotters which have a function to display vector data (superimpose) or are connected with simplified CAD, but there is a clear difference in the recognition of 3 dimensional space when compared with the photogrammetry system which operates on CAD. There is no difference in the acquisition of 2 dimensional data, but the effectiveness of digital photogrammetry system is clear in the application which necessitates the 3 dimensional verification like in the case of our study.

6.2 Output of maps from CAD

The effects of outputting maps from CAD are as follows.

1)Many ground objects were converted into symbols because the priority was placed on the easiness for the users to recognize the topography. As preliminary processing for expressing the topography, many works of processing was necessary for data cleaning and structurization.
2)Temporary output became easy during the course of works.

CAD has played a role as a supplemental tool for the design works but its ability is insufficient for producing good looking prints as the final outcome of the studies. However, the efficiency of work is expected to be improved by making input and edition paying due attention to the expression of final maps from the initial stages based on the experimental results of our present study. Also, the improvement of efficiency at the time of renewal of map due to temporal change as well as frequent renewal of maps are expected by once converting these pieces of information into data.

7 FUTURE STUDIES

The certainty of works to extract ground objects has been enhanced by converting from the process based on analytical plotter to the process based on digital photogrammery system. However, this work is fully dependent on the interactive manual input of data by the operator for the individual objects. In order to enhance the efficiency, we are planning in the future to verify the method to acquire the topographic data in advance, and extract protruding buildings and topographies in blanket.
This study is supposed to have a high affinity with the decision making support using the simulation function which is one of the important roles of GIS. In concrete, the method discussed in this study is considered to be effective for the analysis and numerical conversion of open space (spatial and visual openness) and sunshine rate of wide ranged urban areas.

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