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A UTILITY MAP TRANSFORMATION SYSTEM BASED ON MAP UNDERSTANDING

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ABSTRACT

In recent years some electric power companies or gas suppliers have begun to use computerized utility map management systems. And there is a demand to share their utility data with each other. But that is difficult because their topographic maps, which give the base of equipment location, are different.

So we developed an automatic transformation method of utility data, which transforms utility data for one system to another. This method enables utility map management systems to share their utility data with each other, even if their topographic maps are different.

This transformation method consists of the following two stages;

1) MAP UNDERSTANDING; Topographic maps of two systems are analyzed and skeletons of geographic elements are extracted.

2) MODIFICATION OF EQUIPMENT LOCATION DATA; Correspondence between skeletons of the two maps is established. And the equipment location is modified according to its relative location to the neighboring skeleton.

An experimental system is implemented and the effectiveness of this method is shown.

1. Introduction

There are a lot of equipments on roads for electric power, gas or water supply. And a lot of utility maps are used for their management. Recently, many computerized utility map management systems have been developed and used to reduce the cost of management. [1]

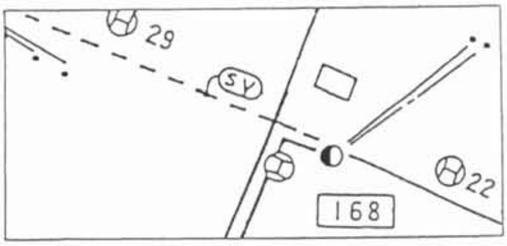
If there are plural utility map management systems, arises a demand to share data of one system with another. But simply overlaying two maps don't do when the topographic maps used as the base of equipment location are different, because relative location of each equipment toward geographic elements is not the same. It is necessary to transform utility map data.

In this paper we present a method of an automatic transformation of utility map data, based on map understanding.

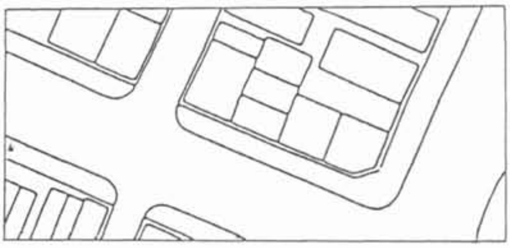
2. Outline of Utility Data Transformation

2.1 Needs of Utility Data Transformation

Fig.1 shows examples of utility maps for electric power supply. In this case, utility maps consist of a series of topographic maps and a series of equipment location maps. A topographic map gives the location of geographic elements such as roads, houses, rivers, sidewalks, etc. —— each of them expressed as a contour. An equipment location map shows the location of equipments such as electric poles, electric lines, transformers, etc. —— each of them expressed as a symbol. Overlaying the two maps, one can understand the relative location of the equipments to the geographic elements.



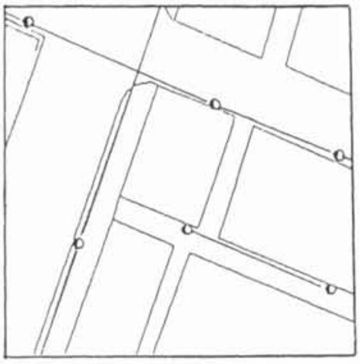
(1) equipment location map



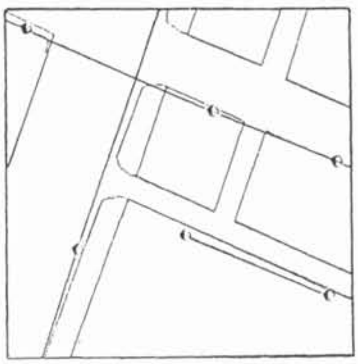
(2) topographic map

fig.1 examples of utility maps

When two utility map management systems use different topographic maps, there are differences caused by measurement error, omission of details, etc. So unless one modifies the utility data, some problems occur. For example, an equipment on a road of an original map becomes out of the road on the other topographic map, namely, target map. (fig.2)



(a) equipments on an original topographic map



(b) equipments on a target topographic map

fig.2 topographic maps overlaid with an equipment location map

Therefore it is necessary to modify the location of each equipment, so that it will preserve the relative location to geographic elements.

2.2 Principles of Utility Data Transformation

Transformation should be done with consideration of differences between the topographic maps. But it is difficult because of the following reasons;

1) A sidewalk on a map may be omitted on another map.

2) An alley on a map may be omitted on another map.

Considering these difficulties, we developed a transformation method that consists of the following two stages; (see fig.3)

a) MAP UNDERSTANDING; Skeletons of topographic maps, which are defined as contours of regions surrounded by roads, are extracted according to the knowledge about structure of the maps.

b) MODIFICATION OF EQUIPMENT LOCATION DATA; Skeleton data is compared to decide correspondence of the skeletons in two maps. Differences between the maps are detected. And based on the differences, equipments are moved from the location of the original map to that of the target map.

Each stage is explained in detail in the following chapters.

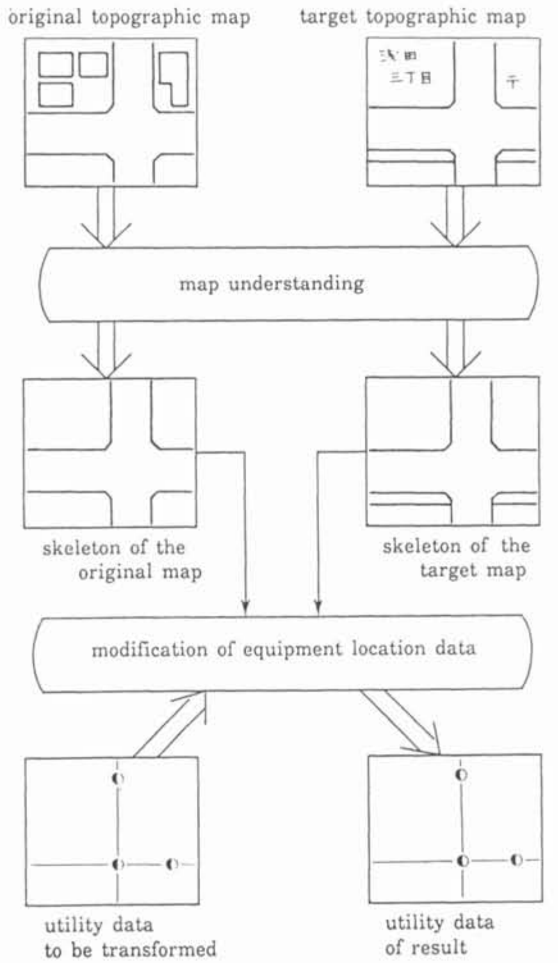


fig.3 concept of the method

3. Map Understanding

3.1 Problems on Map Understanding

The aim of map understanding is to extract skeletons of topographic maps from graphic data. [2][3] (fig. 4)

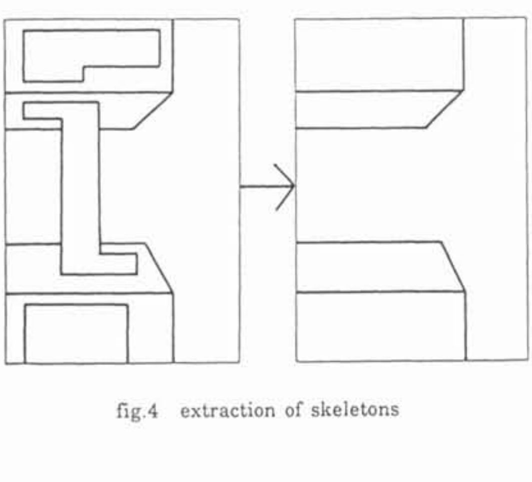


fig.4 extraction of skeletons

The difficult patterns in this stage are as follows;

1) sidewalks; There are sidewalks along the building sites. It is necessary to distinguish the sidewalks from the building sites.

2) footbridges and elevated roads; It is necessary to recover the road lines hidden by them.

To solve these problems we developed a method that uses knowledge about constraints of drawn maps.

3.2 Used Knowledge

The knowledge used in map understanding is divided into the followings;

1) Map model; Knowledge about contents of maps. For example, knowledge about shape of elements such as roads, building sites, sidewalks, etc. And knowledge about possible relation; for example, contact, inclusion or overlap between elements.

2) Analysis rules; Knowledge about the process of map analysis. For example, procedures and strategies of labeling the regions.

The knowledge is described as production rules, whose form is "if··· then···". Conclusion is inferred according to these rules. The flow of the inference is shown in fig.5.

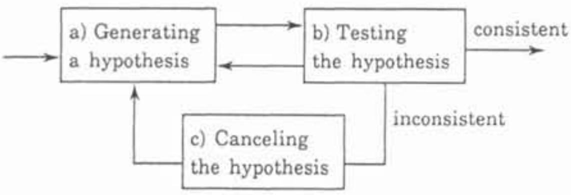


fig.5 flow of inference

a) Generating a hypothesis; According to analysis rules, a possible interpretation about the map is made. For example, if there is a long and slender region, then suppose that it is a sidewalk, and if a line is interrupted, then suppose existence of a hidden elongated line.

b) Testing the hypothesis; According to the map model, the hypothesis is tested. For example, the hypothesis that a sidewalk includes a building, is inconsistent.

c) Canceling the hypothesis; If the hypothesis leads to an inconsistency, it is canceled and the last state is evoked.

'Trial and error' inference steps forward , altering these three modes.

3.3 Flow of Map Understanding

The flow of map understanding is as follows;

1) GETTING CLOSED REGIONS; In the topographic map, graphic data except characters or symbols is usually expressed as groups of short lines. This data is analyzed and closed loops are extracted as regions. At the same time, the features of the region, such as area and circumference, are calculated, and relations between the regions, such as contact and inclusion, are detected.

2) LABELING REGIONS; The extracted regions are labeled as roads, building sites, buildings, sidewalks, etc. This process is accomplished by the inference according to the production rules, explained at 3.2. When hidden lines are supposed, region data is remade, after returning to the process 1).

If all regions are labeled without any inconsistency, the structure of the map is understood successfully.

4. Modification of Equipment Location Data

The principle of modification is that an equipment should be moved, so that it will keep the relative location to the neighboring geographic element.

To achieve this, the location of each equipment is modified as follows; (see fig.6)

1) The basis point Q of the equipment P is fixed on the original map. For example, Q is defined as the nearest point on the nearest skeleton from P

2) The new basis point Q' on the target map, which corresponds to Q, is fixed. For example, Q' is defined as the nearest point on the corresponding skeleton to which Q belongs.

3) The equipment P is moved to the new location P' so that it will keep the relative location to its basis Q. For example, location P' is fixed so that vector PQ will equal to vector P'Q'.

Thus the new equipment location map is made.

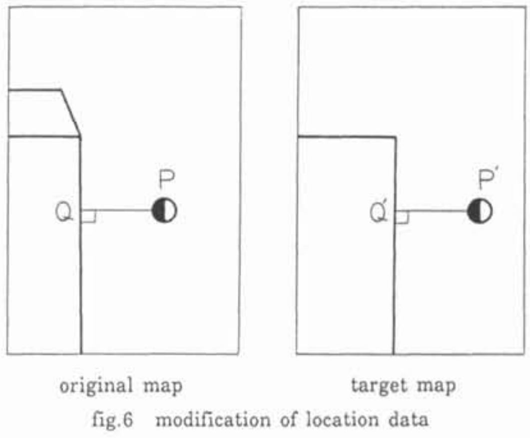


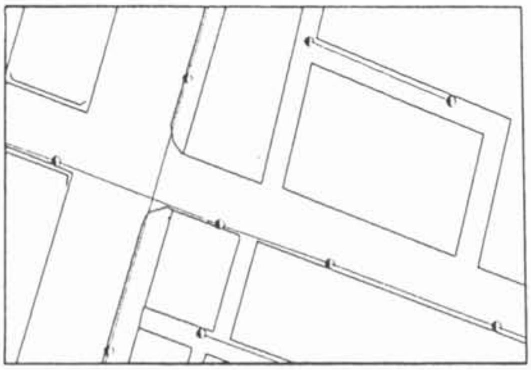
fig.6 modification of location data

5. Result of Experiments

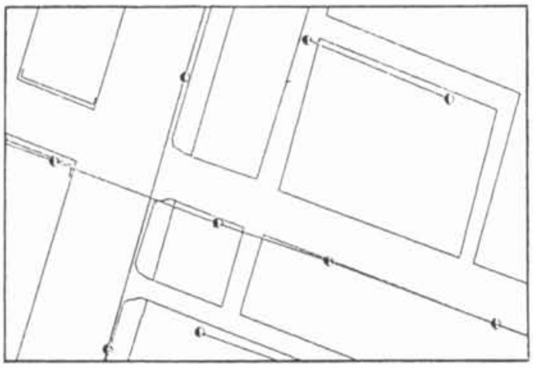
We made an experimental system based on this method and had experiments on the transformation of utility data.

We transformed six utility map data. All 137 electric poles were moved to their suitable places.

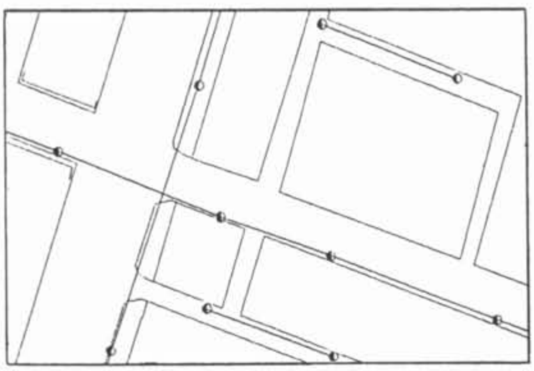
Fig.7 shows an example of the results



(a) equipments on a skeletonized original topographic map



(b) equipments on a skeletonized target topographic map (before transformation)



(c) equipments on a skeletonized target topographic map (after transformation)

fig.7 result of transformation

6. Summary and Conclusions

We developed a method of transformation of utility data. This enables utility management systems to share their utility data with each other.

The method includes following effective techniques of processing graphic data.

1) Map understanding based on the knowledge about drawn maps; this technique enables to process maps with complex structure.

2) Recognition of correspondence between two maps of different origination using skeletons of maps; this technique enables to cope with the variety of maps, which have differences in description rules or measurement errors.

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