Selection of Geospatial Features for Location Guidance Map Generation

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Abstract: This paper proposes a selection procedure of geospatial data for location guidance map generation system. The selection procedure requires some targets appointed by users as input data and outputs geospatial information needed for the map generation. The procedure is embedded in a prototype of object-oriented GIS. We show sample maps generated by the system.

1 Introduction

In posters and leaflets, simplified maps are often used for location guidance since they may be more easily understood than well-precise maps. Simplified maps are generated by collecting necessary road networks and proper landmarks. Therefore, in the realization of generation system of simplified map, the selection of geospatial information is very important. In this paper, we propose a suitable selection procedure which requires some targets appointed by users as input data and outputs geospatial information needed for the map generation. The shape of them is usually deformed to generate a location guidance map. However, the deformation is not treated in this paper.

As a style of location guidance map, the *route* guidance map is well-known. The route guidance maps express the route between a start point and a destination. Landmarks in such maps may be located only along the route. On the contrary, in this paper we consider a general location guidance maps in which no start-destination pair is required but just a target feature is pointed. The selection procedure proposed in this paper selects the roads and landmarks for location guidance from geospatial information surrounding the target.

We developed a prototype of object-oriented geographic information systems(GIS)[4]. In the object-oriented GIS, the fundamental unit of geospatial information is defined as an object, called "feature". We classifies features into two groups RC and NRC such that RC includes only the road features and NRC does the others. We define the neighborhood relation between two features. This can be important factor to select features for the map generation. This paper shows some sample maps generated by the prototype system.

2 Object-Oriented GIS

2.1 Feature model

We developed a prototype of object-oriented GIS[4]. In the GIS, we define the *feature* object, which is the fundamental unit presenting geospatial information. It is composed of the coordinate geometry object and some properties. A feature may be defined recursively, this means that it can be a composite of other features. We refer to the object design of the *feature* in Open Geodata Model (OGM) proposed by Open GIS Consortium(OGC)[5]. Figure 1 illustrates simply the *feature* architecture.

A *Geometry* expresses the geospatial information and is represented by *CoordinateGeometry* and/or *Topology*. A CoordinateGeometry expresses the geospatial information and is represented by a set of Point, Curve, and Surface objects. A Surface is composed of some Curve objects, and a Curve is constructed by some Points objects, and a Point object is the fundamental one of the coordinate geometry. A *Topology* represents topological information and is represented by a set of Node, Edge, Face objects. A Node represents connection relationship of Point, and an Edge represents the relationship of Curve, and a Face represents the relationship of Surface.

A *Property* object is a set of *Item* objects which are composed of a pair of *Key* and *Value*. In most cases, the Key and Value are expressed by string.

2.2 System Architecture

Our GIS employs the multi layer architecture composed of the presentation, the function, and the data layer. Figure 2 illustrates briefly the architecture.

The presentation layer is faced to users, that is, receiving queries, sending searching results, editing spatial data, from/to/by users. The function layer, playing role of various geospatial processing as the middle layer

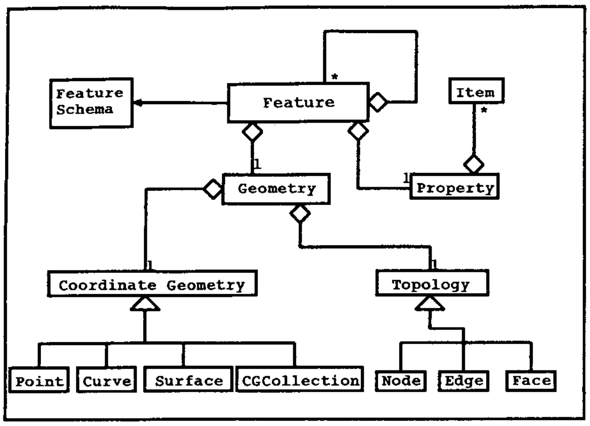

Figure 1: *Feature* Architecture

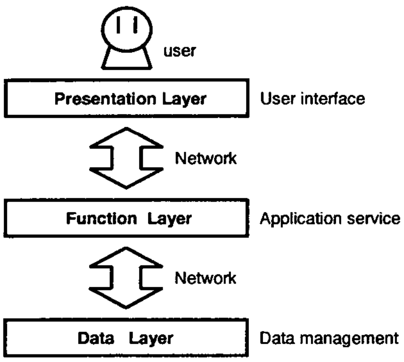

Figure 2: Multi layer architecture

of the system. This is constructed by connecting recursively several function sub-layers. The data layer stores and manages all the data.

3 Simplified Map Generation

The simplified map generation process is divided into the following two steps.

1)Selection process
: Collect the geospatial information to explain the location of the target

2)Deformation process
: Make a map from the collected information with shape deformation

These processes should be develop at the function layer.

Before explaining our proposed procedure, we introduce two concepts, *Important level* and *Neighborhood relation*.

3.1 Important Level

We classify features into two groups RC and NRC such that RC includes only the road features and NRC does the others. And we assign *Important level* to each feature in RC and NRC. The level can be defined in accordance with value assigned socially and/or personally. For example, the public features such as schools or city halls are given higher level. In this paper, we assume that the level assignment is completed by some manner.

3.2 Neighborhood Relation

We define the *neighborhood relation* between two features. This is also an important factor to select features for the map generation. There are two types of neighborhood relation, the relation between each pair of features in NRC, that is, on NRC *timese* NRC and the relation between one in RC and the other in NRC, that is on, RC *times* NRC.

The former is calculated as follows: For each feature in NRC, let us make a circle with a given radius from the center point of the feature and divide the inside space of the circle by drawing 8 radial lines from the center. In each divided area, the nearest feature from the center is characterized as one of the *neighbors*. To calculate this relation we refer to a paper written by Jin[1].

The latter is as follows: For each road feature(in RC), let us find the nearest feature in NRC from the road feature. Features are characterized as *neighbor* if their distance from the road is relatively not far comparing with the nearest feature. This comparison is performed based on "Weber-Fechner's law"[2]. To calculate this relation we refer to a paper written by Fujii and Wakabayashi[3]

4 Selection Procedure

The selection procedure proposed in this paper is divided into two phases:

Road Network Selection
: Select features from RC to construct a road network

Landmark Selection
: Select features from the neighbor features, in NRC, of the target and the road features composing the road network in RC.

4.1 Road Network Selection

Figure 3 shows the road network selection algorithm. Finally, R represents a selected road network.

The road network selected by the algorithm is such that the important level is monotonously increasing from the road neighboring to the target.

Some parameters in the Figure 3 are follows:

R_0**:** a set of roads neighboring to the target

$enqueue(Q, R)$**:** Add all element of R to Q

$dequeue(Q)$**:** pick up the top element of Q

$getP(r)$**:** return the priority of r

$Con(r)$**:** return the set of roads neighboring to r

$getHp(R', p)$**:** collecting the set of roads having higher important level than p from R' and return it

$getEp(R', p)$**:** collecting the set of roads having the same important level as p from R' and return it

```
procedure RoadNetworkSelection
begin
    R := φ;
    Q := φ; // FIFO queue
    enqueue(Q, R_0)
    r := dequeue(Q);
    while (Q ≠ φ) do
    begin
        R := R ∪ {r};
        R' := getAreaIn(Con(r));
        if r has the lowest important level then
        begin
            if getHp(R', getP(r)) ≠ φ then
                enqueue(Q, getHp(R', getP(r)));
            else
                enqueue(Q, getEp(R', getP(r)));
        end
        else
            enqueue(Q, getHp(Con(r), getP(r))
            ∪ getEp(Con(r), getP(r)));
        r := dequeue(Q);
    end
end procedure;
```

Figure 3: Road Network Selection Algorithm

$getAreaIn(R')$: collecting the set of roads satisfying the area condition from R' and return it

Area Condition: the distance from t is shorter than a given fixed value

4.2 Landmark Selection

Figure 4 shows the landmark selection algorithm. Finally, selected objects as landmarks are collected into L. Here, $|R|$ means the size of the set R.

The landmark selection is divided into three steps: First, it selects the features neighboring to the target, and then, the features neighboring to the crossings, finally, other features neighboring to the road network. In the last step, it computes the value of *neighbor's effect* of each candidate feature before the selection. Initial value of it is the important level of the feature. When a feature has higher important level than the focused feature, the value of the focused feature is reduced.

Some parameters in Figure 4 are follows:

R: already selected road network(a set of roads)

R': a set of road between crossings including the roads neighboring to t ($R' \subseteq R$)

L: a set of features(in NRC) : $L = \{l_1, l_2, ..., l_n\}$

C: a set of crossings: $C = \{c_i \in C | i = 1, 2, ..., n\}$

N_0: a set of features(in NRC) neighboring to t

N_1: a set of features(in NRC) except ones having the lowest important level in the N_0 ($N_1 \subseteq N_0$)

N_2: a set of features(in NRC) neighboring to R' and the same side as t

$getMHPL(c)$: return features(in NRC) having the highest important level and neighboring to c

```
procedure LandmarkSelection
begin
    L := φ;
    t := target
Step:1
    if N_1 ≠ φ then
        L := L ∪ N_1
    else if There is a c_i(∈ C) neighboring on t then
        L := L ∪ N_0
    else
        L := L ∪ N_2
Step2:
    for i := 0 to | C | do
        L := L ∪ getMHPL(c_i);
Step3:
    R'' := R ∩ ‾R';
    L' := getHLP(R'');
    for j := 0 to |R''| do begin
        Landmark lm := l'_i;
        calcNE(lm, L');
    end
    L := L ∪ select(L');
end procedure;
```

Figure 4: Landmark Selection Algorithm

$getHPL(R)$: return features(in NRC) except ones having the lowest important level neighboring to R

$calcNE(lm, L')$: calculate *neighbor's effect* of a candidate landmark lm from features in L'

$select(L')$: select the landmarks from the set of candidates L'

5 Examples

We developed a prototype system which implements our proposed selection procedure. This section shows two sample maps generated by the system.

5.1 Data

Figure 5 shows a part of data stored in the system. There is a residential area of a town in Okinawa island in Japan. The black points in the figure represent the targets of location guidance maps. Table 1 summarizes information of the data. In the NRC column, the number inside of parentheses means the number of landmarks except ones having the lowest important level.

In the data, we assign the 4 ranks of important level to the features in RC, and 10 ranks to the features in NRC.

Table 1: Data

Area Size	1600m × 1400m
Number of Features in NRC	3609(81)
Number of Features in RC	654
Total	4213

Figure 5: Data

5.2 Examples

Figure 6 and Figure 7 are maps generated by the prototype system. In this figures, the fixed value of distance from the target is 500m. Example(1) is a map when the target is not neighboring to a crossing, and there are 15 features from NRC and 77 features from RC. Example(2) is a map when the target is neighboring to a crossing, and there are 22 features from NRC and 105 features from RC.

6 Conclusion

This paper proposed a selection procedure of geospatial data for location guidance map generation system. We classified features into two groups RC and NRC, and we assign important level to each feature. Our proposed procedure is divided into two phases: One of them is the selection of features from RC to construct a road network, and the other is from neighbor features, in NRC, of the target and the road features composing the road network.

As future works, we are developing a scheme for simplified map generation system.

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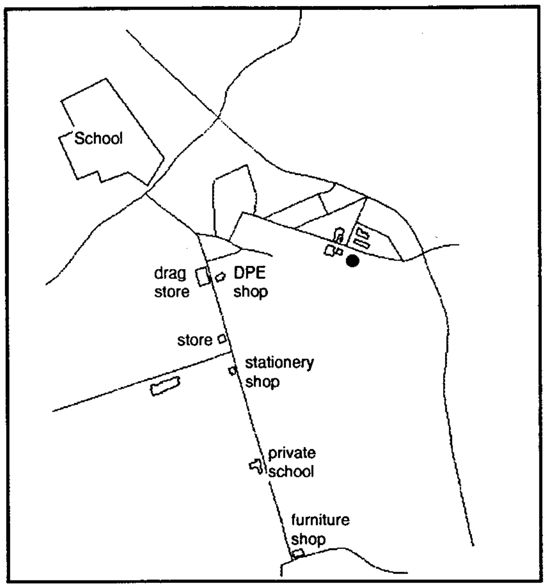

Figure 6: Example(1)

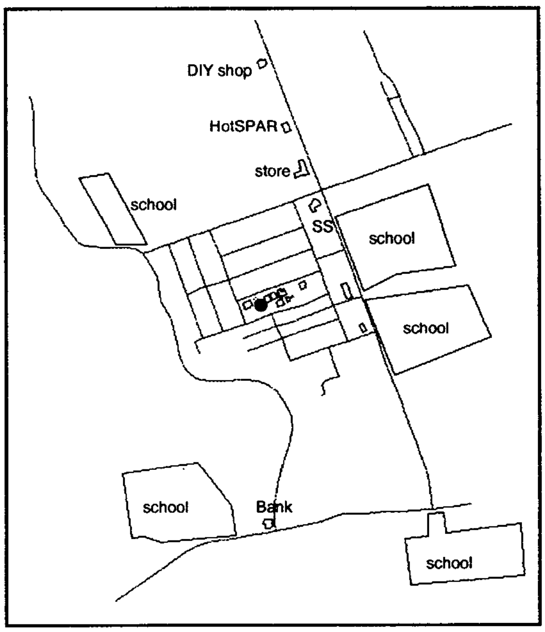

Figure 7: Example(2)