Automated Placement of Street Names on City Map

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Abstract

With the rapid development of the urban construction in China, more attention has been paid to the production of digital city maps. So, it is very important how to place automatically and validly city street names on city maps in computer-assisted cartographic environment. According to principles of cartographic name placement on line objects, the name placement rules on city streets are deduced in this paper. And, a novel approach is presented to automatically convert the labels of the annotation layer into the name attributes of the associated spatial objects. Based on the character of the Arc/Info platform, the paper presents an automated reasoning strategy and mathematical algorithms on the discrete placement of street names. At last, these algorithms are realized on the Arc/Info platform, and a case study is given.

1  Introduction

Manually labeling a map is a tedious task that is estimated to take 50% of total map production time. So, it is very important to place automatically and validly labels on the maps in computer-assisted cartographic environment. It is interesting to note that scientific research results on the Map Labelling Problem have not yet been applied broadly in industry. Several automated placement algorithms have been developed, but mostly not yet are suitable for Chinese character(Barrault and Lecordix 1995). Name placement rules for city streets have been studied only(Chirie 2000). Van Dijk(2002) has given a quality function for label placement methods.

In the next section we will discuss a set of name placement rules for city streets considering the particularity of Chinese characters. A novel approach is presented to automatically convert the labels of an annotation layer into the name attributes of the associated spatial objects in Section 3. In Section 4, we develop a framework for the automated reasoning on discrete placements of street names on city map based on some rules. In Section 5, an example is given.

2  Quantificational name placement rules for city streets

A street name should be placed along the single street centerlines of the road considering the annotation function and the aesthetic effect. Given that a street line is divided by grid that have the same size as that of the character, let \( T \) be a city map, and \( \{ F_i \} (i=1, 2, \ldots, n) \) be the set of streets of \( T \) to be labeled, and \( BN_i \) be the grid numbers between two neighbourly characters, and \( FN_i \) be the grid numbers between the first(or last) character of a label and the node of a street \( i \), the full annotation of a given street is a combination of \( \{ BN_i \} (i=1, 2, \ldots, n) \) , two \( FN_i \)'s and all characters. This is illustrated in Figure 1.
Let $S$ be the font size, and $L_i$ be the centerline length of the road $F_i$. Now then, here is an relation function:

$$LN_i = \text{Int} \left( \frac{L_i}{S} \right) = \text{Int} \left( M_i \left( N_i + BN_i(N_i - 1) + 2FN_i \right) \right)$$

Where $N_i$ is the character numbers of the street name; $M_i$ is the subsection numbers of the street $F_i$. For the full annotation of the given street, Here is an equation:

$$FN_i = \text{Int} \left( \left( \frac{LN_i}{M_i} \right) - N_i - BN_i(N_i - 1)/2 \right) \quad (1)$$

Here we briefly list the major high-level rules on automated placement of street names as follows:

Rule 1: The distance between the street $F_i$’s label and $F_i$ is far less than the distance between the $F_j$’s label and $F_i$, this is, if $i \neq j$, $D_{ij} >> D_{ji}$.

Rule 2: The distance between the street $F_i$’s label and $F_i$ is far less than the distance between the $F_i$’s label and $F_j$, this is, if $i \neq j$, $D_{ij} >> D_{ij}$.

Rule 3: A street name is typically placed along the single centerline of the road, and suitable for the street’s curvature. Text is placed by proportional spacing within the road casing. The character direction is vertical (or parallel) with the street borderline.

Rule 4: All $BN_i$s are same, and lies on $N_i$ and $L_i$. Generally speaking, changing from $0S$ to $5S$.

Rule 5: $FN_i \geq 1S$.

Rule 6: For very long street, the text may need to be placed more than once. The time ($M_i$) lies on $L_i$. Here a formalized criterion is given.

$$M_i = \begin{cases} 
1 & 0cm < L_i \leq 15cm \\
2 & 15cm < L_i \leq 30cm \quad \text{or} \\
3 & L_i > 30cm 
\end{cases} \quad \begin{cases} 
1 & l_i < L_i \leq 2.5l_i \\
2 & 2.5l_i < L_i \leq 4.5l_i \\
3 & L_i > 4.5l_i 
\end{cases}$$

Where $L_i$ is the length of the street centerline on the map, $l_i$ is the length of a street name ($l_i = S \times N_i$). If $M_i > 1$, then $FN_i > 1.5$.

Rule 7: The vertical distance ($W_i$) between a label and the road borderline can not be less than 1mm for avoiding the label to overlap other graphical features. So, $W_i/2 > W_i - S \geq 1mm$.

Rule 8: If the length of a street’s centerline is less than the text length, then cancel.

Rule 9: If there is a littler than 90 degree corner, the name should be placed on two sides of the corner.

Rule 10: At the crossing of streets, labels cannot mutually overlap. Let $T_1$ and $T_2$ denote two labels, $T_1 = \{t_{11}, t_{12}, \ldots, t_{1m}\}; T_2 = \{t_{21}, t_{22}, \ldots, t_{2n}\}$ ($t_{ij}$ stands for a character), here exists an equation: $T_1 \cap T_2 = \emptyset$, and $D(t_{1u}, t_{2v}) >> B_1 \cup D(t_{1u}, t_{2v}) >> B_2$.

Rule 11: If a label spans the crossing of streets, the correlative characters should be symmetrically placed two sides of the corner according to art viewpoint, but sometimes it is very hard to absolutely symmetrize in fact.

3 Automated conversion from street names to street attributes

In the established national digital map data set, labels and geographical features are stored in a different layer, so there is not indirect relation between a label and a spatial object. A novel approach is presented to automatically convert the
labels of the annotation layer into the name attributes of the associated spatial objects. Main steps are as follows:

1. Create it, if there is not the layer of certain road centerline.
2. Calculate the distance between the label \( j \) on the label layer and each street’s centerline \( i \) on the centerline layer. If \( D_{ij} \) is the minimal, and the street width \( W_i > 2D_{ij} \), so \( j \) is regarded as the name attribute of \( i \). Repeat this step until all remaining labels are all handled.
3. Update the centerline attribute list and add name attribute to the list according to the established relation.
4. Check the validity of the label by the human-machine mode, edit and update the attribute list.

4 Reasoning of automated placement for street names

The course of placing street names on a city map is virtually regarded as given the matching street, street name, the parameters of the labeling font, calculating the label position in the map for each character that distributes along the road centerline, and not disturb the map contents according to the quantificational name placement rules for city streets. A automated reasoning on discrete placements of street names is end when a set of \((BN_i, FN_i, M)\) triples is identified. The procedure is as follows:

Let \( StreetN \) be the numbers of street labels, and \( StreetM \) be the numbers of streets labeled.

Step 1. If \( L_i \leq (N_i + 2) \times S \), \((BN_i, FN_i, M_i) = (0,0,0)\), then don’t label, turn to Step 5; otherwise turn to Step 2.

Step 2. Calculate the parameter \( M_i \) based on Rule 6 and Rule 9. If \( LN_{i1} \geq (N_i + 2S) \cap LN_{i2} \geq (N_i + 2S) \), then \( M_i = 2 \); otherwise \( M_i = 1 \). Compute \((BN_i, FN_i, M_i)\).

When \( Repeat = M_i > 1 \), the reasoning is as follows:

If there is no crossing on the street, the street is splited based on Rule 6, and for each segment \( L_{ij} > (N_i + 2) \times S \), \( j = 1,2,\ldots, M_i \); otherwise \( M_i = M_i - 1 \), and splited again. Let Repeat = \( M_i \), and get a record \{the code of the subsection; street name; \( M_i \); the code of the street\}.

If there is a crossing or more on the street, the street is splited at each crossing, then \( M_i \) = the numbers of the crossings + 1, and for each subsection \( L_{ij} > (N_i + 2) \times S \), \( j = 1,2,\ldots, M_i \); otherwise the subsections are merged. \( M_i = M_i - 1 \), let Repeat = \( M_i \), and get a record \{the code of the subsection; street name; \( M_i \); the code of the street\}.

Step 3. Based on Rule 4 and Rule 5, we can compute all possible \((BN_i, FN_i, M)\)s for all subsections, then record \{the code of the subsection or street; \( BN_i \); \( FN_i \); Repeat; the code of the street\}. Let Repeat = Repeat -1. If Repeat = 0, then \( StreetM = StreetM + 1 \), turn to Step 4; otherwise repeat Step 3.

Step 4. According to \{the code of the subsection or street; \( BN_i \); \( FN_i \); Repeat; the code of the street\}, find the maximal value of \( BN_i \) which satisfied Rule 10, and complete locations of all characters based on Rule 3.

Step 5. Let \( i = i + 1 \), if \( i > StreetN \), then \( i = 1 \), and turn to Step 6; or turn to Step 1.

Step 6. If the street \( i \) is formed by only subsection, then turn to Step 7; otherwise check whether or not characters occurs at the crossing of streets, if not, then turn to Step 7; otherwise move the characters to depart from the cross, and turn to Step 7.

Step 7. Let \( i = i + 1 \), if \( i = StreetM + 1 \), then end; otherwise turn to Step 6.

5 Experimental results

The algorithm is implemented on the Arc/Info platform with AML. Figure 2 is a part of a sheet of Guangzhou city map. From the result, the effect of label placement is satisfied. The approach on the problem of labeling city streets here can also be used to handle any type of line-features.
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References


