Recognition of Character Strings from Color Urban Map Images on the Basis of Validation Mechanism

Toyohide Watanabe, Rui Zhang

Reprint

Proceedings of the

International Conference on Document Analysis and Recognition
Volume II

Ulm, Germany
August 18-20, 1997

IEEE COMPUTER SOCIETY

Washington ◆ Los Alamitos ◆ Brussels ◆ Tokyo

PUBLICATIONS OFFICE, 10662 Los Vaqueros Circle, P.O. Box 3014, Los Alamitos, CA 90720-1314 USA

Recognition of Character Strings from Color Urban Map Images on the Basis of Validation Mechanism

Toyohide Watanabe and Rui Zhang
Department of Information Engineering,
Graduate School of Engineering, Nagoya University
Furo-cho, Chikusa-ku, Nagoya 464-01, JAPAN
Phone: +81-52-789-4409, Fax: +81-52-789-3808
E-mail: watanabe@nuie.nagoya-u.ac.jp

Abstract

The map recognition is one of interesting subjects to distinguish the meaningful information automatically from map images and construct resource data in information systems such as GIS (Geographic Information System). However, it is difficult to identify individual information because the map components are mutually intersected or overlayed, and because the properties of map components are not well defined. In this paper, we propose an extraction method of character strings from color urban map images. The characteristic in our method is to validate the identified character strings with map composition rules. Our recognition process is composed of two phases: extraction of character strings; and classification of character strings. The extraction phase is organized by a bottom-up approach, based on the measurement/estimation among pixels, while the classification phase is composed by means of a top-down approach, based on the interpretation/validation among map components.

1 Introduction

The map recognition has been investigated as one of interesting and important subjects with a view to distinguishing various kinds of meaningful information automatically and composing the distinguished information as resource data for construction of application-specific information systems such as GIS (Geographic Information System). Until today, various approaches/methods have been proposed with respect to this subject, but they are not always perfectly applicable. This is because the graphic properties of map components are not well defined and map components themselves are not distinguished clearly by the intersections and overlays among them[1-3]. The subject on map recognition can be maily divided into two research domains: road extraction and extraction of character strings[3-6].

In the recognition of character strings, one problem is that several sizes (or fonts) of characters are used; and another is that the string directions are different by strings such as street names, building names, area names, subway station names, bus stop names, etc. Until today, several researches have been reported with respect to this recognition problem of characters or character strings[3-6]. Many of these researches selected binary-level or gray-level map images as the processing targets. O.Shiku et al. proposed a method based on the voting mechanism, which counts up the number of pixels allocated in templates of character sizes[4]. Also, A.Nakamura et al. proposed an extraction method of character strings, using the dictionary of character strings[5]. These methods do not always provide the generality, but are useful to the recognition of character strings for application-specific urban map images[3]. K.Gyothen et al. proposed an extraction method of characters and character lines, based on multi-agents paradigm[6]. This method is successful on the basis of coordination/negotiation mechanism among agents, which are cooperatively organized so as to check up candidates of character strings assigned inherently to individual agents from a global point of view. However, in this method it is not easy to cooperate among agents effectively less individual agents are appropriately assigned to the corresponding candidates.

On the other hand, we propose an experimental method to recognize character strings on the basis of map composition rules such as properties of individual map components and relationships among map components. In our method the validation mechanism is supported under such map composition rules with a view to checking up by a top-down means whether character strings, which were extracted by a bottom-up means with respect to geometrical features and heuristics, are consistent to other information. In order to achieve this paradigm explicitly, we used color urban map images. In color urban maps, the color information is generally applied so as to make individual map components clear and assist easy readings.

2 Outline of Processing

Our objective is to extract character strings from color urban map images and identify the roles of character strings in urban maps: street names, building names, area names, etc. In this case, character strings are extracted heuristically with respect to the drawing rules, and the meaningful classification is done reliably on the basis of individual properties of map components and the mutual relationships among map components. Figure 1 shows an example of color urban map image.

2.1 Feature of our color urban map

The map components are possibly distinguished by the kinds of colors: for instance,

- white: road
- black: character (for building names, street names, area names, etc), railway line
- dark-blue: bus route, subway route and their station/stop names
- others: areas (by yellow, pink, orange, sky-blue, etc), parks (by green).

It is easy to identify map components individually by these color proporties. We show the results of black and dark-blue images, separated under YSH transformation means, in Figures 2 and 3. Characters are clearly separated in comparison with the original map image in Figure 1. For example, in Figure 2 (of black-colored map image) symbols for indicating buildings are together included. Also, in Figure 3 (of dark-blue-colored map image) bus/subway routes and their attended symbols are observed. We can arrange the features of characters and character strings as follows:

1. In black-colored map image, street names, building names, area names, railway station names, block numbers, etc are included;
2. In dark-blue-colored map image, station/stop names in bus/subway routes, street numbers, and blunch numbers are included;
3. Building names associate the corresponding building symbols near to themselves;
4. Area names are surrounded, color by color, with the corresponding colored areas;
5. Sizes of characters are different by their roles of map components;
6. Station/stop names associate the corresponding symbols near to themselves;
7. String directions of station/stop names are approximately allocated along the directions of their routes.

2.2 Processing flow

Our method is fundamentally organized under the validation mechanism: the hypotheses are first generated, string by string, on the basis of properties of characters/character-strings, and then the hypotheses are validated with respect to the geometric/spatial relationships among character-strings/other-map-components. In Figure 2, we can classfy the character strings into building names if the character strings are associated with building symbols close to themselves. For example, if a character string "大久手" could be related to the symbol "〒" (this symbol indicates a post office in Japanese map), this character string can be regarded as the post office name. Also, if a character string "大久手町" could be surrounded with one colored area, this character string can be looked upon as the area name.

Figure 4 illustrates our processing flow. As discussed above, our processing flow is divided into three phases: preprocessing, extraction of character strings, and classification of character strings. In the preprocessing phase, individually filtered color map images are generated from the original color urban map image, using YSH transformation. The black-filtered and dark-blue-filtered color map images are mainly used to extract and classify character strings, hereafter. In the extraction phase, first character regions are individually extracted from the previously filtered map images, using some techniques in the ordinary character recognition. Next, character strings are heuristically composed from character regions with respect to the properties of individual characters. In the classification phase character strings are identified/classified into map information with individual meaningful roles.

3 Extraction of Character Strings

This phase is composed of two steps: extraction of character regions; and identification of character strings.

3.1 Extraction of character regions

The extraction step is necessary to distinguish the areas corresponding to characters. In this urban map 6 kinds of character sizes are used. This constrain is very useful to identify characters with different sizes effectively. Namely, this fact is applied strongly to merge and partition some candidates for character-like regions even if they are intersected, overlayed, or separated (i.e. "木" and "票" in "標", "日" and "光" in "晃", etc). Also, these character sizes are used to describe different map components. Table 1 shows the correspondences between character sizes and meanings of map components.

This extraction step consists of four procedures: estimation of character regions, merging of intersected character regions, merging of separated character regions, and arrangement of character regions by character sizes. The estimation of character regions is performed by using 8-connection method. Figure 5 is the result of character regions arranged/normalized so as to make up individual character regions reasonably in case that character regions are mutually overlayed.

3.2 Identification of character strings

The length of character strings illustrated in urban maps is, in many cases, 2 or 3[6]. Of course, the strings of 3 or more characters are always used because the character strings are representative names for real existing objects in maps. Here, we consider mainly character strings whose length is 2 or 3. If the length is 4 or more, we can consider repeatedly by dividing into (3,2) or (2,3): (3,2) represents that the length of the first string is 3 and the length of the second string is 2; and the third character is included at once in both strings. Thus, we extract appropriate character strings on the basis of various relationships between two characters or among three characters.

(1) Relationships between two characters

- connectivity: two characters of the same string are mutually close.
- similarity of size: sizes of two characters in the same string are almost similar or same.

(2) Relationships among three characters

- linearity: three characters in the same string are allocated on the same line.
- equality: three continuous characters in the same string are located with almost equal gaps.

The result is shown in Figure 6.

4 Classification of Character Strings

The classification phase checks up whether extracted character strings are not inconsistent as correct strings and determines what individual character strings indicate as map components. This classification phase is organized under the validation mechanism, and is divided into three steps: identification of area names, identification of building names and identification of bus-stop/ subway-station names.

4.1 Identification of area names

Character strings of area names are generally described by maximum sizes of characters and are surrounded with the areas (refer to the feature 4. in Section 2.1 and Table 1). The feature about area name in Table 1 is not useful if character strings of largest size are wrongly connected with characters of other strings. Also, the feature 4. in Section 2.1 means that the area always surrounds character strings of largest size. However, the area may not be closed because the strings break off the boundary lines. Of course, this feature 4) is a key so that candidates of extracted strings should be validated as the area names. In order to make this validation procedure well, we must extract the corresponding areas themselves clearly, first of all. The procedure is composed as follows:

Step1: Check up colors of areas corresponded to character strings. After having got rid of colors of character strings from corresponding areas for every area, estimate colors of the remaiders.

Step2: Fill in corresponded areas with estimated colors, respectively.

Step3: Extract areas of individual colors. In this case, areas of same color are not always continuous, because areas are often broken off by roads.

Step4: Estimate width of roads H included in each area.

Step5: Expand each area in four directions if same colored areas are found out within width H. As a result, these areas are merged.

Step6: Compute maximum and minimum lengths of closed areas with same color length in X- and Y-axes.

Using such colored areas, character strings are validated correctly: if the string is uniquely closed by extracted area, this string is determined as the area name. Of course, though the extracted area may contain other strings such as building names, the feature 5. in Section 2.1 (or Table 1) is not satisfied. Figure 7 is the result of character srings identified as area names, using the features in Table 1.

4.2 Identification of building names

In our urban map, many of building names associate the corresponding symbols (refer to the feature 3. in Section 2.1). We can arrange the geometric relationships between building names and associated symbols in Figure 8. The procedure for checking up these geometrical relationships is composed as follows:

Step1: Check up the geometrical relationships between character strings and character/symbol areas located closely to strings. And, compute distance "d" between center line of character string and center point of character/symbol area.

(a): "d" is defined as distance between center line of character string and center point of character/symbol area.

(b): "d" is defined as distance between center point of terminal character area of center line of character string and center point of character/symbol area.

(c): "d" is defined as same as (b).

Step2: Select character/symbol area as associated symbol area if "d" is less than twice of character size of string. In this case, select associated symbol area with minimum distance "d" if many candidates are selected as associated symbol areas.

Figure 9 shows character strings identified as building names from Figure 7.

4.3 Identification of bus-stop/subway-station names

It is not difficult to identify bus-stop/subway-station names from our filtered map image (dark-blue colored map image in Figure 3). Additionally, these names are described along the routes.

5 Concluding Remark

We implemented the prototype system on SUN Sparcstation-10, using the programming language C. In this experiment, color urban maps of 1/20,000 are scanned in 300 dpi and the image size is 500*500 pixels. Our recognition method of character strings from colored urban map images, based on the validation mechanism, is proved to be effective through experiments. Although currently proposed methods are dependent only on heuristics, our method focused on the relationships among map components in addition to the properties of characters.

In our future work, the following subjects should be investigated: refinement of processing algorithms; and development of backward control, based on the cooperation among different identification procedures.

Acknowledgements

We are very grateful to Prof.T.Fukumura of Chukyo University, and Prof.Y.Inagaki and Prof.J.Toriwaki of Nagoya University for their perspective remarks, and wish to thank our research members for their many discussions and cooperations.

References

[1] T. Hayakawa, T. Watanabe, Y. Yoshida and K. Kawaguchi: "Recognition of Roads in an Urban Map by Using the Topological Road-network", *Proc.of MVA'90*, pp.215-218.

[2] T.Watanabe, T.Hayakawa and N.Sugie: "A Cooperative Integration Approach of Bottom-up and Top-down Methods for Road Extraction of Urban Maps", *Proc.of ICARCV'92*, pp.61-65.

[3] M.Nishijima and T.Watanabe: "An Automatic Extraction Approach of Road Information on the Basis of Recognition of Character Regions", *Lecture Notes in Computer Science 1024: Image Analysis Applications and Computer Graphics*, pp.173-180(1995).

[4] O. Shiku, M. Anekawa, C. Nakamura and A. Nakamura: "Extraction of Characters from Maps", *trans.on IPSJ*, Vol.34, No.2, pp.273-280(1994)[in Japanese].

[5] A.Nakamura, O.Shiku, M.Anekawa, C.Nakamura and M.Kuroda: "A Method for Recognizing Character Strings from Maps, Using Linguistic Knowledge", *Proc.of ICDAR'95*, pp.561-564.

[6] K.Gyohten, T.Sumiya, N.Babaguchi, K.Kakusho and T.Kitahashi: "Extracting Characters and Character Lines in Multi-agent Scheme", *Proc.of ICDAR'95*, pp.305-308.

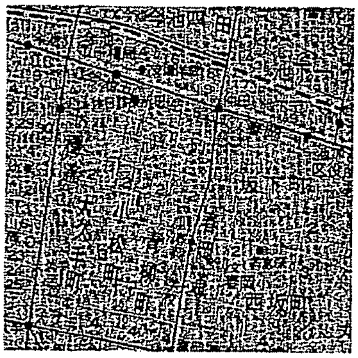

Figure 1 Urban map image

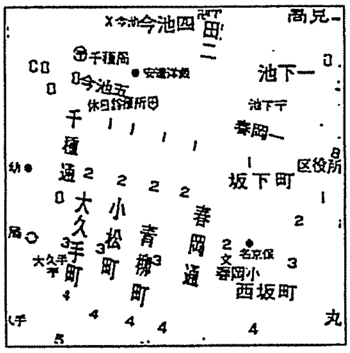

Figure 2 Map image filtered by black

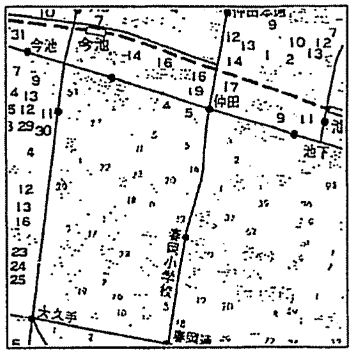

Figure 3 Map image filtered by dark-blue

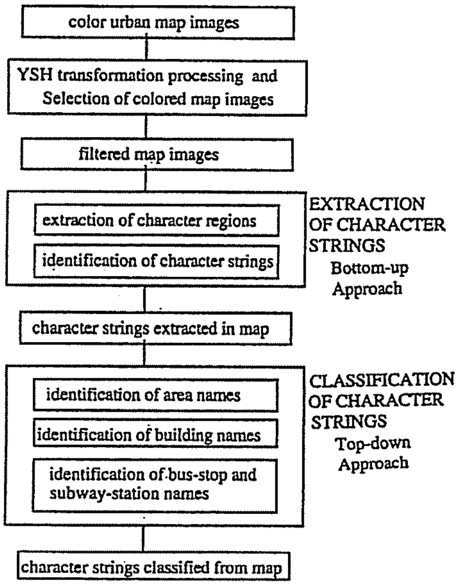

Figure 4 Processing flow

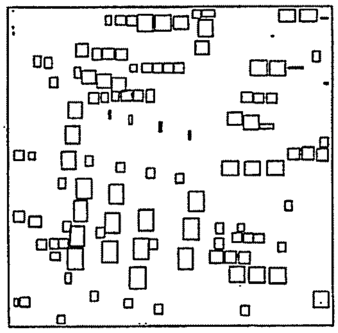

Figure 5 Arranging character regions

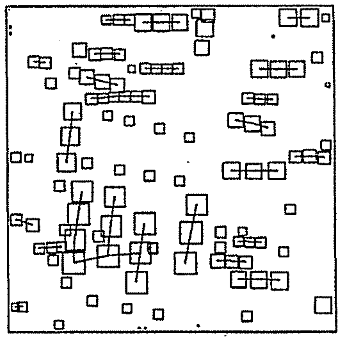

Figure 6 Identification of character strings

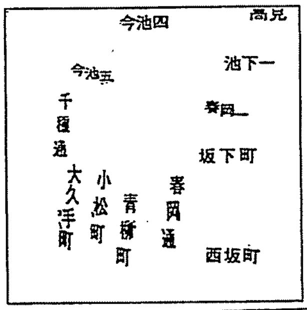

Figure 7 Character strings identified as area names

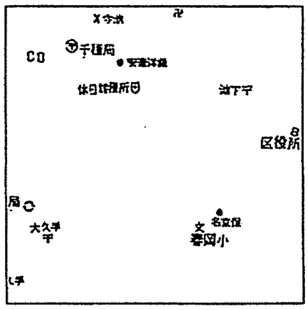

Figure 8 Character strings identified as building name

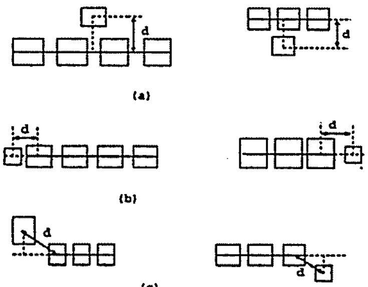

Figure 9 Geometrical relationships between building names and associated symbols

Table 1 Character sizes used in urban map (Length unit: pixel)

No.	Length in X-axis	Length in Y-axis	Usage
1	25	35	Area name
2	25	25	Area name, Building name
3	20	20	Building name, Bus-stop/subawy-station name
4	15	15	Building name
5	10	15	Number, Symbol
6	10	10	Symbol