デフォルメ地図のための作成意図抽出に基づく信憑性分析

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あらまし　観光地の所在地情報などを手軽に取得するために，Web 上のデフォルメ地図を利用することがある．しかしながら，過剰な強調，削除などにより，デフォルメ地図作成者の意図を反映した地図になっておらず，信憑性が疑わしい場合が存在する．そこで，デフォルメ地図と周辺テキストから地図の作成意図を抽出し，意図に対するデフォルメ地図の整合性を分析する手法を提案する．

キーワード　情報信憑性，デフォルメ地図，作成意図，時空間 DB

A Credibility Analysis Method based on Editor's Intention for Modified Maps

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Abstract　Modified maps are widely used for making it easy for someone to find locations such as sightseeing spots and shops. However, excessively modified maps often lack credibility. Because of most modified maps are not kept up-to-date with changing the real world, and mistakenly or exaggeratedly maps where they are made intentionally or not are often problematic. In other words, these maps do not accurately reflect the editor's intention. We propose a credibility analyzing method based on various measures for analyzing consistency and determining a map editor's intentions. Our proposed method is used to optimize measures of analyzing consistency based on a map editor's intentions. We assume there are three kinds of intentions for modifying maps such as explanation of directions, positions of geographical objects, and starting and destination points. We also assume that credibility analysis involves looking at a modified map's consistency with the real world and the web page. In this paper, we analyze credibility based on inaccurate maps and how much they differ from what the editor intended.

Key words　Information Credibility, Modified map, Editor's intentions, Spatio temporal DB

1. Introduction

Online digital maps represented by Google Maps [3] are nowadays widely used to support daily decision making such as nearest restaurant search or travel planning. However, we often struggle with incorrect information in a briefly modified map, which might lead us to lose a way toward a destination. For example, a user way to find restaurant with an out-of-date map not reflecting on most up-to-date geographic object's names such as movement or closing. Therefore, it is critical to estimate the correctness of online maps in terms of credibility. Indeed, there are many possibilities of such situations when we have to depend on the online maps. Especially, among them, modified maps mostly used in a lot of sites are valuable due to some critical reasons. First, as like the aforementioned problem, the updates of all the changes possible in the real world are hard to be connected instantly with all the modified maps. Second, mistakenly or exaggeratedly maps where they are made intentionally or not are often problematic.

There are two types of digital maps available on the Web. One is an online map, and the other is a modified map. Online maps are represented by, for example, Google Maps, Yahoo! maps, and Bing maps. The user can manipulate an online map interactively by, for example, moving, zooming-in, and zooming-out. This type of map is made for generalpurpose. Therefore, shapes, positions, and presentations of geographical object such as city, restaurant, and mountain are correct. On the other hand, modified maps are static images. That is, they are not interactive. Modified maps are made for specific purposes such as route guides and showing the position of geographical objects. Map editors can transform geographical objects on a modified map for their own purposes by emphasizing or deleting.

Modified maps are often used on "access information" web pages. If we can analyze the credibility of modified maps, we can further develop various systems such as retrieving modified maps based on credibility ranking, replacing a modified map on a web page to a more credible, and revising non-credible parts for creating credible maps.

We present a consistency analysis method for measuring map credibility. In particular, our method is used for optimizing measures of analyzing consistency based on the intentions of modifying a map that are extracted from the surrounding text on an access page. We define three types of editor intentions and four of measures for analyzing consistency.

This paper is structured as follows. Section 2 explains our approach and reviews related works, Section 3 describes editor's intentions, Section 4 explains analyzing consistency, and we end the paper with concluding remarks in Section 5

2. Our Approach

2.1 Overview of Our Method

Our proposed method is used to optimize measures of analyzing consistency based on a map editor's intentions (Figure 1). We assume there are three kinds of intentions for modifying maps such as explanation of directions, positions of geographical objects, and starting and destination points. We also assume that credibility analysis involves looking at a modified map's consistency with the real world and the web page. Consistency with the real world means that a modified map shows the correct positions of objects as they are in the real world. Consistency with a web page means that a modified map is suitable for a specific purpose stated on the page. In other words, we analyze credibility based on inaccurate maps and how much they differ from what the editor intended. We assume that we can extract a geographical object's name and position from modified maps using, for example, optical character recognition techniques.

In modified maps, we consider that there are tree types of object as a destination, starting, and passing object. The destination object shows the location of modified map's purpose. The starting object, such as the nearest station, landmark, and present location, shows a convenient starting location for arriving at the destination object. A passing object, such as an intersection, and landmark, follows the route to the destination object. We use these objects type for determining editor's intention. We define four types of consistency analyzing measures as approximate positional relations, relative distances, showed objects, and represented regions. In addition, approximate positional relations and relative distances are a spatial consistency, and showed objects and represented regions are a consistency between the modified map and surrounding texts. We proposed a method of optimizing above-mentioned measures for analyzing consistency based on the intentions of map editor that are extracted from the surrounding text on an access page.

We explain our proposed method by explaining the positions of objects. First, we extract destination objects, starting objects, and passing objects based on the structural features of the surrounding text such as HTML, and inclusive relation between two geographical objects included in the text. Next, we determine the editor's intention of modifying a map using these extracted objects. When there are more destination objects than passing and starting objects, we determine that the editor's intention is showing destination objects' positions. In this case, we analyze measures of consistency to approximate the positional relation between destination and starting objects, and coverage of showing destination objects and represented regions.

These measures are important for explaining the positions of objects; however, relative distance is not important. If the positions of objects are correct, a user can correctly use the modified map irrespective if the distance between each visible object on the map is too long/short.

2.2 Related Work

2.2.1 Generating Modified Maps

Methods for generating modified maps have been extensively researched. These studies can be divided to selecting objects, transforming the shapes of objects, and arranging the position of objects. First, we describe methods of selecting objects. Arikawa et al. [1] proposed detecting visible objects using ontology of geographical objects for adapting users purposes. Shimada et al. [10] and Nakazawa et al. [5] developed a method for selecting objects using attributes such as type and position. Then, we explain methods of transforming the shapes and arranging the positions of object [2], [4], [8], [11]. A common approach is simplifying borders such as roads, coastline, and edges of building into straight lines and right angle based on the cognitive science of maps. Then, objects are arranged using morphing techniques to simplify distortion. These studies aim to generate wanted modified map by users. Our proposed method is used for determining an editor's intentions, and analyzing suitable uses for those intentions.

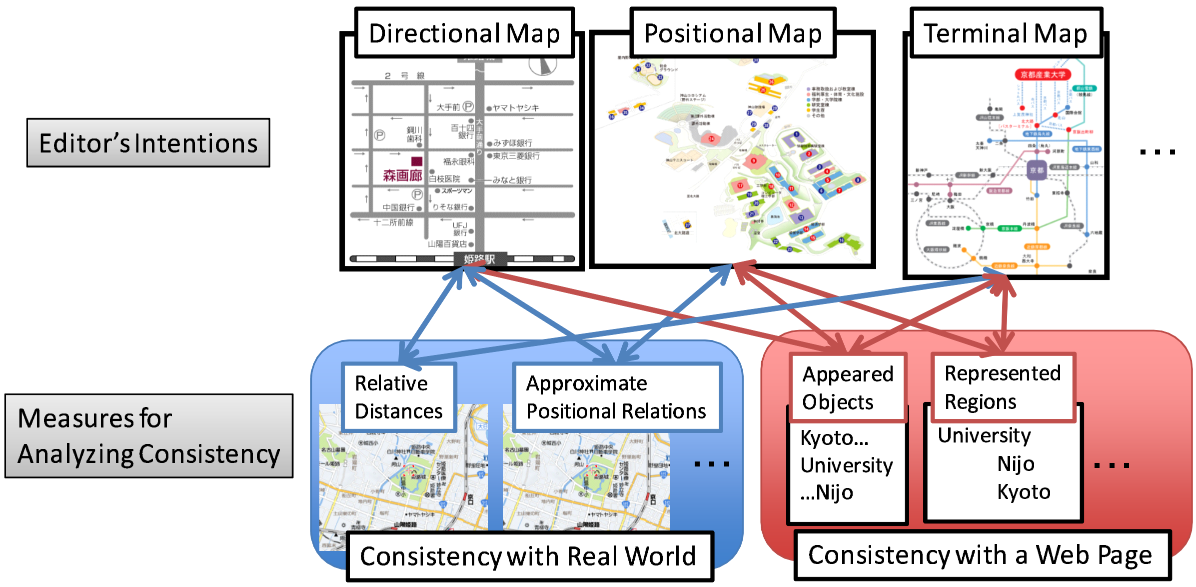


図 1 Concept image of credibility analysis

2. 2. 2 Analyzing Information credibility

Methods of analyzing the credibility of various types of information have been investigated. Kessler et al. [7] introduce next generation gazetteer system. They propose a environment of geographic information contribution and retrieval. In this system, they collect volunteered geographic informations. Therefore, they detected a trustiness of information using users contribution models. In digital maps, users contributions are not available. Therefore, we propose determining the consistency of objects using content-based analysis. Nakamoto et al. [9] proposed a method of tag-based collaborative filtering for improving the credibility of recommendations. They determined user similarity using social tagging for collaborative filtering. User credibility is an important factor for recommendations, and tag-based analysis is a reasonable method. However, detection of the consistency of objects is needed for content-based analysis of digital maps and web pages. Kawai et al. [6] proposed a method of using a sentiment map for visualizing the credibility of news sites. Their method is used to analyze sentiment about news articles and visualize the analyzed sentiment on a digital map. Their aim was to detect sentiment biases for determining the credibility of news sites. Digital maps were used only to visualize user sentiment. Our aim is to detect the consistency of real-world objects using online digital map.

3. Editor's Intentions on Modified Maps

3. 1 Types of Modified Maps based on Editor Intentions

Modified maps are created for various purposes, for example, directions and showing an object's position. Therefore, editors have various intentions when they create a modified map. We consider that the credibility of a modified map differs depending on the types of editor's intentions. We define editor's intentions as follows.

Directional map This type of map is for guiding someone to a destination object. It includes a destination object and many of passing objects as landmarks. The route is the most important thing in this map. Therefore, users believe that distances and positional relations between each object are consistent, and there are enough passing objects to help show the way.

Positional map This type of map is made for showing positions of one or more destination objects. The position is most important things in this map. Therefore, users believe that positional relations between each object are consistent, there are enough destination objects included, and the represented region is large enough for showing the positions of the destination objects.

Terminal map This type of map is made for showing simply routes to a destination object. It includes a destination object and many starting objects. The routes between starting and destination objects are the most important things in this map. Therefore, users believe that distances between starting and destination objects are consistent, there are enough starting objects included, and the represented region is large enough for reaching the destination object.

3. 2 Determining the Roles of Geographical Objects from Surrounding Text

In this section, we explain the extracting roles of geographical objects from the surrounding text. We extract tree types of roles of a destination, starting, and passing object. The destination object shows the location of modified map's purpose. In other words, we consider that all of modified maps

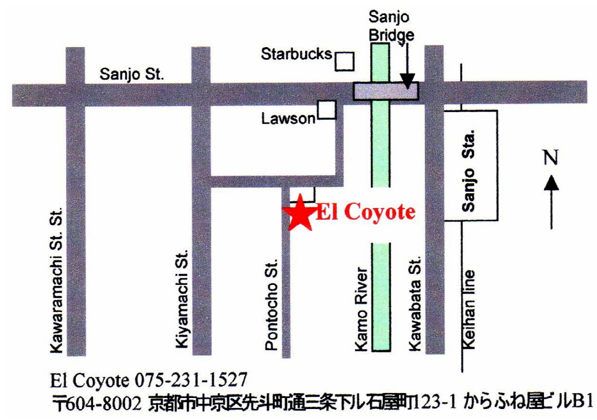


図 2 Example of the directional map

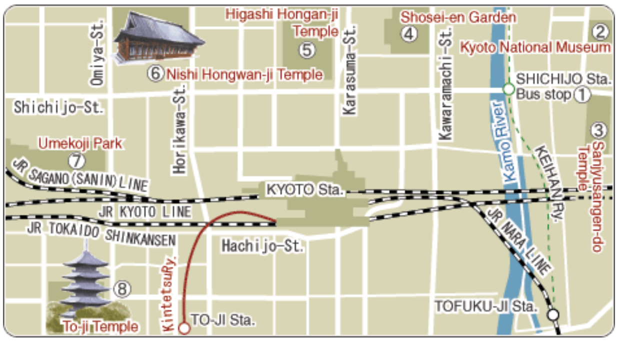


図 3 Example of the positional map

図 4 Example of terminal map

are focused on the destination object. Therefore, a destination object must be included on modified maps. A starting object, such as the nearest station, or landmarks, and present location, shows a convenient starting location for arriving at the destination object. Passing objects, such as intersections, and landmarks, follow the route to the destination object. We define the roles of destination objects (D), starting objects (S) and passing objects (P) as follows:

$$D = \{d | (d \in T \wedge |I| < |O|) \vee (d \in I \wedge |I| > |O|) \vee (d \in C)\} \quad (1)$$

$$I = \{i | r(i) \in r(t)\} \quad (2)$$

$$O = \{o | r(o) \notin r(t)\} \quad (3)$$

$$C = \{c | \text{c has same pattern on HTML trees}\} \quad (4)$$

$$S = \{s | \text{"from.*}s\text{"} \in Sen\} \quad (5)$$

表 1 Determining editor's intentions

	$\|D\|$	$\|S\|$	$\|P\|$
Directional map	1	$\geqq 1$	$> \|S\|$
Positional map	$\geqq 1$	$\leqq 1$	0
Terminal map	1	$\geqq \|P\|$	$\geqq 1$

$$P = \{p | \text{"[on | via | cross | before | along | get off at].*}p\text{"} \in Sen\} \quad (6)$$

where T is a set of geographical objects in the web page's title, t is a element of T, function r returns an object's region, I/O is a set of geographical objects included/excluded in t's region, C is a set of geographical objects that match the pattern of HTML structures. S is extracted by using keywords which means leaving any location such as "from" on a sentence Sen of a web page, and P is extracted by using keywords which means performing action such at a location such as "via" on a sentence Sen of a web page.

Definitions of stating objects and passing objects are depended on the language. Therefore, we should define rules as detecting role for each language.

3.3 Determining Editor's Intentions using Roles of Geographical Objects

We consider that an editor's intentions are represented by number of roles of each geographical object. For example, when an editor thinks of the actual route when he/she makes a modified map, that map may include many passing objects because passing objects are effective as guides on a route. Therefore, we determine an editor's intention based on the number of roles of each geographical object.

In Table 1, $|D|$ is the number of destination objects, $|S|$ is the number of starting objects and $|P|$ is the number of passing objects. A directional map has one destination object and one or more starting and passing objects. There are more passing objects than starting objects. A positional map has one or more destination objects and zero or one starting object. This map does not have any passing objects because they are unnecessary for showing objects' positions. A terminal map is similar to a directional map. However, there are more starting objects than passing objects.

4. Credibility Analyzing Measures for Modified Maps

4.1 Adaptation of Measures for Editor's Intentions

Our method is used to change the combination of consistency analyzing measures depending on the editor's intentions. Table 2 lists the measures used. Rows are the editor's intentions, and the columns are the measures of analyzing consistency. D is a set of destination objects, S is a set of

表 2 Analyzing measures for each kind of intentions

	Relative distances	Positional relations	Appeared objects	Represented regions
Directional map	D and P, S and P	all	P	unused
Positional map	unused	S, D	D	too wide
Terminal map	S and D	unused	S	too narrow

starting objects, and P is a set of passing objects. Credibility analysis consists of consistency with the real world and with the web page. Consistency with the real world means that a modified map should show the correct positions of objects, that is consistent with the relative distances and approximate positional relations. On the other hand, consistency with the web page means that a modified map is suitable for a specific purpose, that is consistent with visible objects and represented regions.

In a directional map, we use relative distances, positional relations, and visible passing objects because these measures are important for directions. If the distances and positional relations are wrong, users cannot reach the destination object. On the other hand, if there are not enough passing objects, it will be difficult for users to understand the route information.

A positional map shows the positions of destination objects. Therefore, we use positional relations, visible destination objects, and represented regions, which are important for showing positions when analyzing consistency. Users misunderstand objects' positions if the positional relations are wrong. On the other hand, if there are not enough destination objects, this map does not represent its purpose. When the represented region is too wide, the user cannot confirm the destination object's position.

In a terminal map, we use relative distances, visible starting objects, and represented regions because these measures are important for showing the different routes to destination objects. When the relative distances are wrong, users may select the wrong stating object. If there are not enough starting objects, users cannot compare each route. On the other hand, a user who wants to start from a far location cannot find a convenient route when he/she uses a modified map that represents a region that is too narrow.

4. 2 Analyzing Consistency with Real World using Online Maps

4. 2. 1 Consistency of relative distances

We explain consistency with the real world in detail. Consistency with the real world is calculated with online maps that represent the real world. In a modified map, we have to use a analyzing measure that is suited for the modifications. Therefore, our method is used to analyze the relative distances and approximate positional relations. In this section, we describe the consistency of relative distances. The relative distance is analyzed from only distance relations between two objects. In other words, we check for inconsistency of the distance between a modified map's and online map's objects.

We use the following expression for calculating relative distances.

$$Dist = 1 - \frac{6\sum {dist_i}^2}{n(n^2-1)} \times \frac{1}{2} \tag{7}$$

We use Spearman's rank correlation coefficient, which returns a score between -1.0 and 1.0. We use this formula to measure the consistency of relative distance. Therefore, we divided by 2 for transform to a range of score between 0.0 and 1.0, where $dist_i$ is the difference in distance of two objects between a modified map and an online map. n is a number of object pairs. Figure 5 shows an example of relative distances. The consistency of relative distances is 0.875, which is high.

4. 2. 2 Consistency of approximate positional relations

In this section, we describe the consistency of approximate positional relations. Analyses of the approximate positional relation only focuses on the direction whether the target object is in the right or it is in the left when another object is seen from a certain object. We compare if directions are the same between a modified map's and online map's objects. An object far from the target objects is unimportant in terms of approximate positional relations. If the position of the far object is wrong, we can assume that this object's position was modified. However, when the position of near object is wrong, users wrongly assume that their objects' positions are correct.

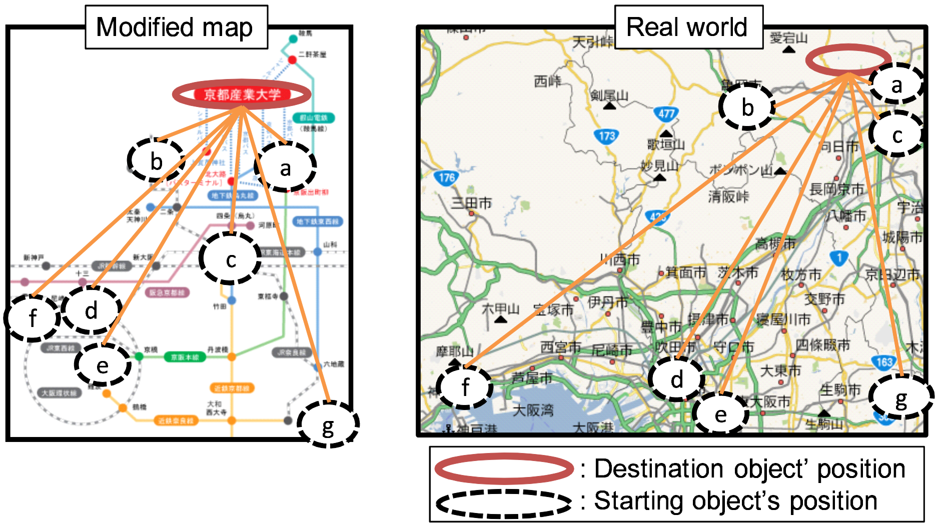
We explain the approximate positional relation of a positional map as follows:

$$Pos = \frac{\sum_{d_i \in D} pos(d_i)}{|D|} \tag{8}$$

$$pos(d_i) = 1 - \sum_{d_j \in D, d_i \neq d_j} (c(d_i, d_j, s_x) \times \frac{min(dst(d_i, d_j), dst(s_x, d_j))}{\sum_{d_j \in D, d_i \neq d_j} min(dst(d_i, d_j), dst(s_x, d_j))}) \tag{9}$$

$$c(d_i, d_j, s_x) = \begin{cases} 1(\text{the same position on online maps}) \\ 0(\text{different position on online maps}) \end{cases} \tag{10}$$

where d_i is a destination object, d_j is another destination object, s_x is a starting object, $dst(d_i, d_j)$ is the distance between two objects, $pos(d_i)$ calculates the degree of positional correctness of an object, and $c(d_i, d_j, s_x)$ returns 1 when these



Order of distance	In modified map	In real world
1	a	a
2	b	c
3	c	b
4	d	g
5	e	d
6	f	e
7	g	f

図 5　Example of relative distances

objects' positional relations are the same with those on online maps.

4.3 Analyzing Consistency with Web Page from Surrounding Text

4.3.1 Consistency of Visible Objects

We explain consistency with a web page in detail. Consistency with a web page is calculated from the surrounding text as representing the purpose of the web page. Our method is used to analyze visible objects and represented regions. In this section, we describe the consistency of visible objects. We assume that there is a set of objects that should be included in a modified map depending on the editor's intentions. For example, if a modified map shows a sightseeing map, this map should include all sightseeing spots in this area. The visible objects are analyzed to see if there is an agreement the surrounding texts.

We extract objects that should be included in a modified map from the surrounding text using the following steps.

(1) We search web pages using D or S.

(2) We select web pages that include the roles of D or S.

(3) We extract each object by the following conditions.

$$D' = \{x | x \in D \vee (x \in X \wedge \frac{X \cap D}{X \cup D} > \alpha)\} \quad (11)$$

$$S' = \{y | y \in S \vee (y \in Y \wedge \frac{Y \cap S}{Y \cup S} > \beta)\} \quad (12)$$

$$P' = \{z | z \in P \vee (z \in Z \wedge (x \in X \wedge x \in D) \wedge (y \in Y \wedge y \in S)\} \quad (13)$$

where X is a set of destination objects in a searched web page, and Y and Z are sets of starting and passing objects in a searched web page.

We use these sets of objects for calculating the consistency of visible objects.

$$T = \begin{cases} P'(\text{directional map}) \\ D'(\text{positional map}) \\ S'(\text{terminal map}) \end{cases} \quad (14)$$

$$Obj = \frac{|T \cap M|}{|T|} \quad (15)$$

where T is an object set from the surrounding text, and M is an object set included in a modified map. When a map is intended to be directional, T and M represent sets of passing objects. When a map is intended as positional, T and M represent sets of destination objects, and when a map is intended as terminal, T and M represent sets of starting objects.

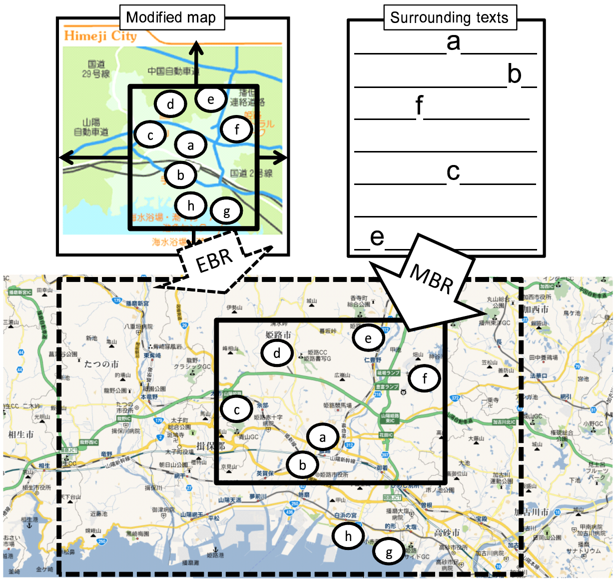


図 6　Example of represented regions

4. 3. 2 Consistency of Represented Region

In this section, we describe the consistency of represented regions. The represented region is analyzed to see if there is agreement with the surrounding text. We assume that if a modified map has too wide/narrow a region, users will not understand the purpose of the modified map. For example, when a positional map has too wide a region, destination objects may be too crowded together in an area.

We calculate the consistency of the represented region using the following formula.

$$Reg = \begin{cases} min(1, \frac{MBR(T)}{EBR(M,m)}) \text{ (positional map)} \\ min(1, \frac{EBR(M,m)}{MBR(T)}) \text{ (terminal map)} \end{cases} \quad (16)$$

where function MBR returns the minimum bounding rectangle (MBR) of an object set, T is an object set in the surrounding text, and M is an object set on a modified map. EBR returns the estimated bounding rectangle (EBR) of modified map m. We estimate the longitude and latitude on a modified map using $MBR(M)$. We calculate the rate of an $MBR(M)$'s x axis and longitude and an $MBR(M)$'s y axis and latitude. Then, we translate x and y axes to longitude and latitude using that rate. Figure 6 shows an example of represented regions. The modified map is a positional map, and the EBR (dashed rectangle) of modified map is larger than the MBR (solid rectangle) of the surrounding text, In this case, a user cannot confirm the positional credibility using this map because geographical objects are overcrowded on that part of the modified map.

5. Evaluation

We evaluate determining editor's intentions using actual web pages. We use 10 web pages as a data set for this evaluation. This data set consists of 8 web pages which include geographical objects on the page title and 2 web page which exclude geographical objects on the page title. There are a modified map and surrounding texts in each web page. In this evaluation, we extract geographical objects from a web page manually.

Table 3 shows experimental results of determining object's roles. We extracted geographical objects by each rule that defines at section3. 2 . Precisions are calculated by extracted correct objects as each role and extracted objects by each rule. Recalls are calculated by extracted correct objects as each role and correct objects as each role. In these results, we confirmed that our definition can be extract each object's role.

Table 4 shows result of determining editor's intentions. We confirmed that editor's intentions can be determined by our proposed method. In a few case, our proposed method determined incorrect intentions. Two maps which are positional maps are not extracted any intention because some geographical objects are determined to passing objects as incorrect role. Figure 7 shows a result of incorrect intention. In this map, we extracted 10 directional object such as "Imperial Palace" and "Ryotei Sakaguchi" from contents of web page because these objects are contained by geographical region of "Kyoto" which is included in title of web page. However, we extracted one passing object as "Sannenzaka" by the keyword "along". Therefore, our proposed method do not determined any intention in spite of this modified map is positional map correctly. Passing object's precision and recall are low because extracting rule of passing object is loose. We should define passing object as strict. In a directional map, extracted destination object and starting object are incorrect, however the number of each role object match the rule of the directional map by accident.

6. Concluding Remarks

We proposed a method for analyzing credibility using consistency analyzing measures and editor's intentions. We define consistency with real world and with web pages for modified maps. By this method, users know the accuracy of a map and the display validness of a web page depending on the editor's intentions.

We will develop a prototype system using our proposed method. We will also evaluate a method for each consistency analyzing measure and for extracting editor's intentions. Furthermore, we will apply our method to a retrieval system of modified maps based on credibility.

7. Acknowledgments

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表 3　Result of determining object's roles

	destination object	starting object	passing object
precision	0.84 (61/73)	0.93 (13/14)	0.56 (9/16)
recall	0.97 (61/63)	0.93 (13/14)	0.56 (9/16)

表 4　Result of determining editor's intentions

		determining by system			
		directional map	positional map	terminal map	other
determining by human	directional map	3	0	0	0
	positional map	0	2	0	2
	terminal map	0	0	3	0

[Title]
Enjoying **Kyoto** - **Kyoto** City Tourism and
Culture Information System

[Contents]
Imperial Palace & Kaiseki Cuisine
● Destinations (in random order):
Kyoto **Imperial Palace** (depends on day),
Restaurant **Ryotei Sakaguchi** (lunch: Kaiseki cuisine),
Strolling *along* **Sannenzaka** (Ryozen Kannon statue),
Toji Temple, **Sennyuji Temple**, **Chishaku-in Temple**
● Departure Place & Time
JR Kyoto Stn (Karasuma Exit) 10:20
Keihan Rlwy (**Sanjo Stn**) 9:55 (coach does not return
to **Sanjo**; tour ends at **Kyoto Stn**; coach does stop at
Keihan Rlwy **Gojo Stn**)
...

図 7　An example of extracting incorrect intentions

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