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Cinematic Street: Automatic Street View Walk-Through System using Characteristics of Modified Maps

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We propose a system to transform a modified map into a streaming video based on intentions of the modified map's producer. A modified map is shown geographical information which the modified map's producer wants to express. Even if two similar geographical objects appear on multiple modified maps, implication of geographical objects differs among objects by around geographical objects. For instance, in a modified map, the two objects are shown as same kinds of tourist spots. On the other hand, in a modified map, an object is shown as tourist spots and an object is shown as landmarks. Therefore, we determine a producer's intentions of a modified map by extracting equivalence relations among geographical objects. In addition, we determine types of a modified map based on a producer's intentions. Moreover, we propose methods of representing streaming video based on types of a modified map.

1. Introduction

A modified map refers to a map that is simplified to suit specific purposes. Modified maps contain deformed geographical objects that fulfill these purposes. For instance, when only a store is emphasized on a modified map containing various geographical objects, these objects are indicated as landmarks to serve as directions to reach the store. On the other hand, when similar types of geographical objects are emphasized equally, they are selected using certain relations. The abovementioned important points on a modified map differ based on the types of geographical objects and the relations among the positions of these objects. Thus, we consider that each modified map conveys its maker's intentions, for instance, by showing important points using the geographical objects selected by the maker. Therefore, even if one or more geographical objects on multiple modified maps are the same, the implications of the modified maps differ on the basis of the types of surrounding objects that show the information required by each maker.

In addition, in order to provide visual information to users, it is effective that a maker adds photographs and images of geographical objects on a modified map. Consequently, on the basis of the photographs and images on the modified map, the important points that the maker wants to show become clear, and hence, it is easy for users to understand the modified map. However, it is difficult for the maker to add substantial visual information because the increased space required by the photograph makes it difficult to understand the modified map and to observe the geographical information below the photographs on the maps. This observation of geographical information along with the visual information is required by makers of modified maps Apart from photographs and figures, video pictures can also be used in modified maps A video picture can transmit a substantial amount of information as it has a temporal axis. If the maker expresses his/her modified map as a video picture, users can understand the modified map. However, it is not realistic for a maker to develop a video picture.

Therefore, we propose a system to transform a modified map into a streaming video. This streaming video is a video picture generated by connecting the movement obtained on Street View. Street View is the best tool to express information of modified maps, because it can display local geographical information [1] [4] [5] [6] [18] [22] [23]. This system is often used to explore locations by walking and describing real space in a virtual space. Further, the Street View has some other attractive services [8] [20]. In this way, the Street View is an attractive new media. However, the Street View is not effectively utilized by users. We utilize Street View to transform a modified map into a streaming video.

In Section 2, we provide an overview of our research and related works. We discuss the extraction relations among geographical objects on modified maps and the determination types of modified maps in Section 3. In Section 4, we describe ways to employ Street View based on the types of modified maps. In Section 5, we discuss our experiments. Section 6 provides the conclusion and a discussion of future works.

2. Approach

2.1 Concept of Cinematic Street

Cinematic Street refers to streaming video content with which modified maps information can be automatically viewed as a video (Figure. 1). Thus, this system transforms a modified map into streaming video automatically. Therefore, this system is beneficial to makers of modified maps because it can be used to show streaming videos to users according to their intentions. Additionally, we consider that the system is beneficial to makers as well as users because it is designed to facilitate a better understanding of modified maps among users. For instance, when a maker wants to effectively show tourist spots by means of a modified map, he/she will add photos and draw illustrations of each tourist spot. However, users find it difficult to understand the information of a modified map when a maker adds numerous photos and illustrations. Therefore, if a system exists for transforming a modified map made by the maker into a video, the maker does not have to add detailed information to the modified map. In addition, if users view this system, they may clearly understand the geographical information in the modified maps. This system consists of two steps: determining the

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maker's approach to representing his/her modified map and transforming the modified map into a streaming video based on this approach. These steps are explained in greater detail below.

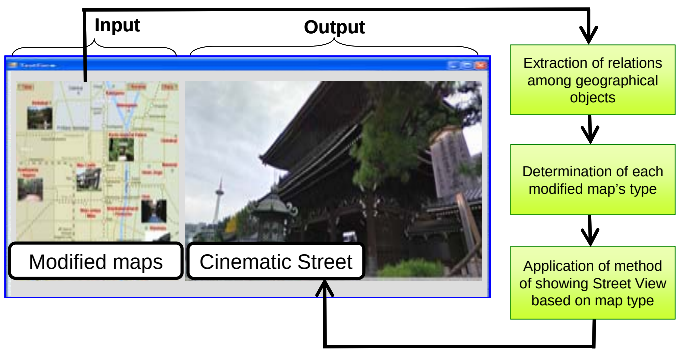

Figure 1: Outline of Cinematic Street

When a modified map is made, first, geographical objects are selected from a normal map and located on the modified map. Therefore, a modified map is made based on the intentions of the maker. For instance, a modified map indicates routes among various objects by showing objects connected by paths. On the other hand, a modified map containing many tourist spots shows the sightseeing spots themselves; this is because showing these objects is the purpose of the modified map. In the former case, relations among objects on the modified map are not equivalent, but in the latter case, the relations are equivalent. Therefore, we consider the importance relations between the maker's approaches to representing the modified maps and the equivalent relations among geographical objects. Consequently, it is possible to estimate the methods of representing modified maps by determining the equivalent relations among geographical objects and analyzing the positioning relations among paths and objects.

Secondly, the ways in which a maker intends to show a video are different. For instance, when a maker wants to show a route to a certain place, it is necessary for the video to show the path. On the other hand, when a maker wants to show the surroundings of a certain place, it is necessary to turn the camera in different directions. Conventional researches have been conducted on the methods of representing videos such as those described above. Therefore, we transform a modified map into a stream video by applying conventional methods based on maker's methods of representation. We utilize Street View, which displays local information for visualization of modified maps.

2.2 Preliminary Experiments

We experimented to confirm the types of makers' intentions. In this preliminary experiment, we provided a questionnaire on ten sheets of modified maps to thirteen university students. We asked them two questions "What does a modified map show? Please write it freely." and "What does a modified map show? Please select one of the following choices; Route, Objects, Both and Others."

Modified maps are classified into three types on the basis of makers' intended relations among the paths and objects: "Route map," "Object map," and "Mixed map." We consider this classification to be apt as these three types of maps account for approximately 90% (Table 1). In this paper, we discuss a method of determination and transformation in these three types of modified maps.

Table 1: Result of preliminary experiment

	Routes	Objects	Both	Others
Map 1	0.31	0.54	0.15	0.00
Map 2	0.23	0.23	0.31	0.23
Map 3	0.38	0.38	0.23	0.00
Map 4	0.00	0.23	0.31	0.46
Map 5	0.23	0.38	0.38	0.00
Map 6	0.31	0.31	0.38	0.00
Map 7	0.08	0.31	0.46	0.15
Map 8	0.23	0.38	0.31	0.08
Map 9	0.23	0.08	0.46	0.23
Map 10	0.08	0.62	0.31	0.00
Total	2.08	3.46	3.31	1.15

2.3 Related Work

2.3.1 Modified Maps

Previously, users were able to easily create modified maps using Destination Maps of Bing Maps [1]. The generation of modified maps in this service has been studied extensively [11] [15] [16] [21] [27] [30]. Fujii et al. [13] [14] proposed a method for generation of guide maps for mobile devices. They analyzed the features of guide maps and classified the maps as route-type, survey-type, and deformation-type maps. In any of these cases, they did not analyze the type of the modified maps because they focused only on the generation of modified maps. However, it is necessary to analyze the type of modified maps to show a streaming video based on the type of modified maps.

2.3.2 Extraction of the Relation among Geographical Objects

Previously, research has been carried out to extract equivalent relations among geographical objects [28]. This study utilized the scales of online maps. The system identified geographical objects with same appearance pattern as the objects that the user chose in regard to equivalent relations. The scales of modified maps such as online maps cannot be changed, and we believe that not all geographical objects on modified maps have equivalent relations. In our research, it is necessary to extract the conceptual relations among geographical objects in order to describe the type of modified maps. Shiina et al. [7] discussed the methods of adding the characteristics of geographical objects by calculating the degree of association of these objects using the co-occurrence relations among geographical objects in web pages. However, they did not focus on the equivalent relations among geographical objects, because they focused on the depth of the relations. We utilize equivalent relations to determine the type of modified maps, because we consider that there exist equivalence objects on modified maps such as tourist maps.

2.3.3 Method of Showing Multimedia Contents

Various fields employ various approaches to presenting visual information [10] [17]. In these fields, camera movement is not required because the images are still images. However, Street View requires camera movement because it shows a direction.

On a related video picture, there are various film languages [31]. Additionally, there are several methods for showing a video picture [3] [12]. When interactive tasks are performed, some other systems concentrate on finding the best camera placement [2] [9] [24] [25] [26] [29]. He et al. [19] proposed a Virtual Cinematographer in which the virtual architecture is suitable for some real-time applications and is well related to the virtual actors. In these researches, target objects are moving objects such as characters and a camera can recognize target objects. However, target objects on Street View in this research are geographical objects that do not move. In addition, Street View cannot recognize target objects. Therefore, it is necessary to show an original method for recognizing target objects on Street View.

3. Determination of Intention for Creating a Modified Map

In this section, we discuss the definitions of geographical objects and the equivalent relations among them and the extraction of these relations in order to extract meaning which a modified map describes on the basis of geographical information on the map. In addition, we present the determination type of modified maps using positional relationships among geographical objects.

3.1 Definition of Geographical Objects

Here, we define geographical objects. Geographical objects are defined as the place names on the modified maps, with the following attributes: name, position on the map, multiple categories, and a type (path or node). For example, Market Street is a geographical object in San Francisco and is included in categories such as “Streets in San Francisco, California,” “Shopping districts and streets in the United States,” and “Lincoln Highway.” On the other hand, University of California, Berkeley, is included in categories such as “Educational institutions established in 1868,” “National Register of Historic Places in the San Francisco Bay Area,” and “California Historical Landmarks.” Our system identifies roads, streets, and roadways as paths when geographical objects belong to the category including “Street”. Targeted geographical objects, such as stations, temples and shrines, universities, and institutions, are called “nodes.” In the abovementioned examples, the former categories refer to the categories of paths and the latter are examples of nodes.

These categories are conceptual hierarchies with a DAG (Directed Acyclic Graph) structure. We utilize these conceptual hierarchies to extract equivalent relations among geographical objects. Concepts with the same hierarchical level have a similar level of abstraction. In this work, prefectures and municipalities, mountains, and rivers are exempted from geographical objects.

3.2 Extraction of Equivalent Relations among Nodes

Here, we provide the definition of equivalent relations. Equivalent relations among nodes imply that the concepts of the nodes are semantically similar. Thus, when there are nodes at the same hierarchical level with respect the perspective that a maker wants to show, the relations among these nodes are equivalent relations. Therefore, relations of nodes differ for each modified map. We can regard the theme of the modified map category class as a typical nodes class on the modified map.

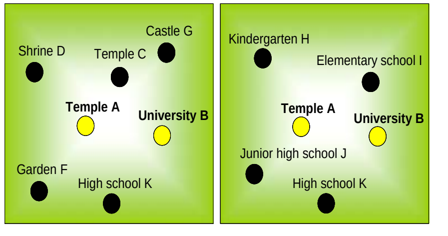

Figure 2: Example of equivalent relations among nodes

We describe the process of extracting the relations among nodes. We consider that even if the same nodes appear on several modified maps, these objects do not always have equivalent relations. For example, in the case of Figure 2, “Temple A” and “University B” appear on two modified maps. Here, “University B” is an old historic piece of architecture. In these maps, equivalent relations of two nodes differ on the basis of the types of surrounding nodes. In the left modified map, we can assume that the two nodes are equivalent relations because the map shows the positional relations of the nodes involving "cultural heritage." On the other hand, in the right modified map, we can assume that the two nodes are not equivalent relations because the map shows positional relations of nodes of "educational institutions."

Consequently, we first extract the typical categories of the modified map and extract the nodes at the same distance from the typical categories as equivalent relations. Additionally, there are other relations among nodes, such as landmark relations and inclusive relations; however, we focus only on the equivalent relations in this paper.

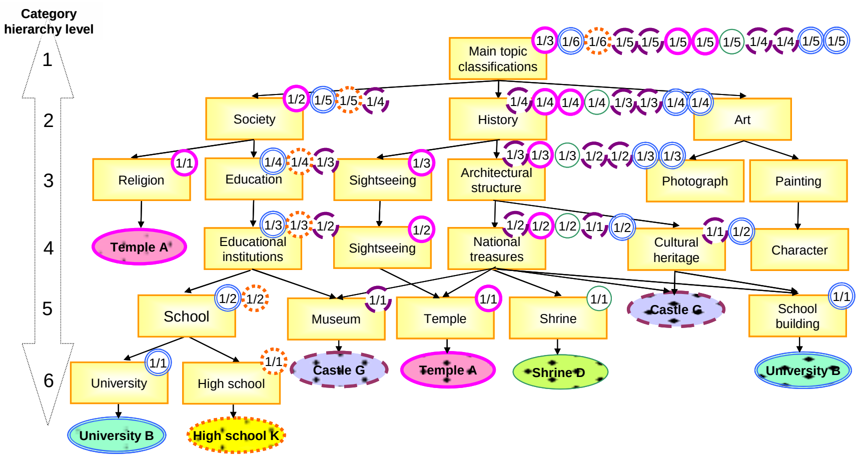

Figure 3: Procedure to extract equivalent relations

We describe the specific procedure for extract the relations among nodes.

1. The categories to which nodes on a modified map belong are determined, as shown in Figure. 3.
2. The weights are added from all descendent nodes to each category. The weights of the category are determined by each distance from descendent nodes which are elements of the category. When a category is close to a node, its weight is high. On the other hand, when a category is distant from a node, its weight is low. The category value is calculated by adding all the weights corresponding to the category (Figure. 3).

$$Category(a) = \sum_{o_i \in O} \frac{1}{dis(a, o_i)} \quad (o_i \ is\ a's\ descendant) \qquad (1)$$

3. When a value is higher than the threshold, the system determines the typical categories. In Figure. 3, a typical category is "National treasures."
4. When there are nodes in the same hierarchical level from a typical category, they have equivalent relations in the typical category. In Figure. 3, nodes of equivalent relations are Castle G, Temple A, Shrine D, and University B.

3.3 Determination of Type of a Modified Map

In this section, we describe the approach to determining the type of modified maps. We consider that we can determine the intention of creating the modified maps by classifying the groups into paths and nodes; this is because we believe that the positioning of paths and nodes differ on the basis of the intention of creating the modified maps. For instance, if many nodes that are not bound by equivalent relations are shown and connected by many paths, the modified map shows routes among the nodes. On the other hand, if few paths are shown and many nodes with equivalent relations are shown, the modified map shows the positional relations among specific nodes.

We first present the features of each modified map. Route maps are modified maps that show some paths between two nodes; hence, paths are important for Route maps. Object maps are modified maps that show various nodes; hence, nodes are important for Object maps. Mixed maps are modified maps that show nodes existing in the vicinity of paths; hence, both paths and nodes are important for Mixed maps.
The system groups the geographical objects in a modified map to detect their features. Accordingly, we consider that the classification of modified maps is possible in keeping with the path and node trend of a group unit. We show the procedure below.

1. The minimum spanning tree is composed of the layout of the path and the node, as shown in Figure. 4(a).

$$Geographical\ Objects = \{path_1 \sim path_n, node_1 \sim node_m\} \qquad (2)$$

2. Grouping is performed by considering the minimum spanning tree as an order tree. Determination of ordering is a preorder traverse based on the order tree. Geographical objects range in an increasing numerical order from left in the tree.
3. The first *node* or *path* is added to $Group_j$. If there are other elements under the elements of $Group_j$, the system considers the next geographical object.
4. If the next geographical object is $path_{i+1}$, it is added to $Group_j$. If the next geographical object is $node_{i+1}$, and the relations among the elements of $Group_j$ and the *node* is equivalent, $node_{i+1}$ is added to $Group_{j+1}$. If there are other elements under $Group_{j+1}$, the system considers the next geographical object.
5. If there are no other elements under the elements of *Group*, the *Group* is closed.
6. The steps 4 and 5 are repeated until it follows all geographical objects.

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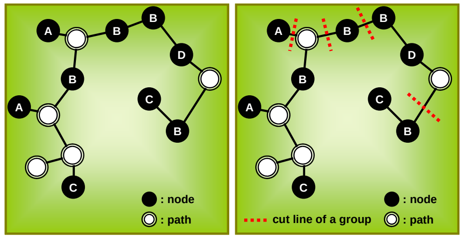
Figure. 4(b) illustrates the grouping from node C on the left. The alphabets denote the equivalent relations among nodes. On the basis of their grouping, our system classifies modified maps into "Route map," "Object map," and "Mixed map."

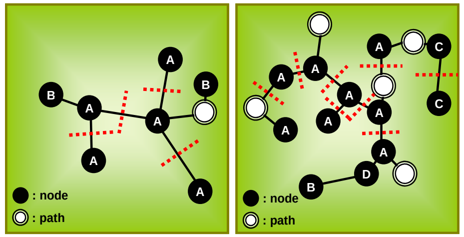
- Route map
  The important factors in a Route map are paths. Therefore, the system calculates the number of all geographical objects in a modified map and the number of geographical objects in the groups that include paths. When the number of geographical objects in the groups is above a threshold, the map is determined as a Route map. We decided that the threshold value is half of the number of all geographical objects determined in the preliminary experiments. In the case of Figure. 4(b), the total number of geographical objects is 14, so the threshold value is 7. The number of geographical objects in 3 groups that include paths is 12 and is larger than the threshold. Therefore, this modified map is determined as a Route map.



(a) Minimum spanning tree (b) Determination of grouping
Figure 4: Grouping of minimum spanning tree

- Object map
  The important factors in an Object map are nodes. When the number of groups that include only one node or one node + paths is above a threshold or the map is not determined as a Route map, the map is determined as an Object map. In Figure. 5(a), the first node is node B on the left. The number of geographical objects is 8, and the number of groups is 5. The map is not a Route map because the number of geographical objects that include paths is 1. Moreover, the number of groups that include only one node or one node + paths are 3. Therefore, the modified map is determined as an Object map.

- Mixed map
  The important factors in a Mixed map are both paths and nodes. When the map meets the requirements of being both a Route map and an Object map, it is determined as Mixed map. In Figure. 5(b), the first node is node A on the left. The map satisfies the requirement of being an Object map because the number of geographical objects is 17 and the number of groups is 9. The number of groups that include only one node or one node + paths is 7. Therefore, the map is an Object map. In addition, the map meets the requirement of being a Route map because the number of geographical objects in groups that include paths is 13. Accordingly, the map is determined as a Mixed map.



(a) Object map (b) Mixed map
Figure 5: Example of determination type of modified maps

4. Transforming a Modified Map into a Streaming Video based on the Intention of Creating a Modified Map

In this section, we discuss the method of transforming a modified map into streaming video based on the maker's intention of creating the modified map. The conventional method of representing a video based on the film syntax is applied to Street View. First, we describe the film syntax. Secondly, we propose a method of showing streaming video based on the types of a modified map. Lastly, we explain an application of the significant impact of the relations among geographical objects.

4.1 Proposed Method of Showing Streaming Video based on Type of a Modified Map

As conventional method of capturing a video, there are various shots such as "pan," "tracking shot," "180° line," "graphic math" and "establishing shot," and there are various transactions such as "cut," "fade-in/fade-out," "dissolve," "wipe" and "iris-in/iris-out." We apply these representation methods for the film to Street View.

The targets for representation in a film are "subjects," "characters," and "objects." On the other hand, targets in our work are "intentions of a maker," "paths," and "nodes." We apply innovative methods of film to Street View to represent the intentions of makers. The following are the types of Street View effects obtained in each modified map using our system.

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- Route map

It is important to show the routes from a departure node to other nodes because the paths between nodes are important factors in a Route map. Therefore, the system shows the routes among nodes on a modified map by means of streaming videos.

First, a user selects a departure node. The flow route from a departure node to another node is as follows:

I. When the order of geographical objects is "node, path, node," the system searches for a route. Next, if nodes exist after the path, then multiple nodes are allowed.

II. The Cinematic Street is moved across the surrounding of the departure node from left to right as in the "establishing shot," because this movement is necessary for users to comprehend the surroundings.

III. The Cinematic Street on the paths is aimed toward the corner or the arrival node and advances in steps of three toward the destination; it uses effects such as "180 ° line" and "tracking shot," because these effects are used because the route is unidirectional.

IV. The Cinematic Street shown in the third step is moved from the corner or the arrival node and advanced toward the corner or the arrival node with effects such as the "180 ° line" and "tracking shot," because this is because it is necessary for users to recognize movement along the route.

V. If the next point is a corner, the system moves to step VI, and if next point is the arrival node, the system moves to step VII.

VI. The Street View of the corner is shown from left to right using an effect such as "pan," because it is necessary for users to notice important points.

VII. The Street View of the places close to the arrival node is shown using effects such as the "establishing shot," because it is necessary that users comprehend the surroundings of the arrival node.

VIII. When this process is completed, the system moves to the next departure node and follows the same steps.

- Object map

An Object map is needed to show a relationship between dotted nodes because nodes are important factors in an Object map. The system shows the Street View based on equivalent relations among the nodes.

First, a user selects a node as a departure node.

I. The Cinematic Street shows the departure node and equivalent relations nodes in order by using an "establish shot" because it is necessary for users to comprehend the surroundings of each node.

II. The nodes of equivalent relations can be justified by Cinematic Street using a "graphic match" because it is necessary for users to recognize relations among nodes.

III. The Cinematic Street is used to show the appearance of nodes using the "pan" shot because it is necessary for users to recognize the appearance of nodes.

IV. Nodes that do not have equivalent relations at random are shown.

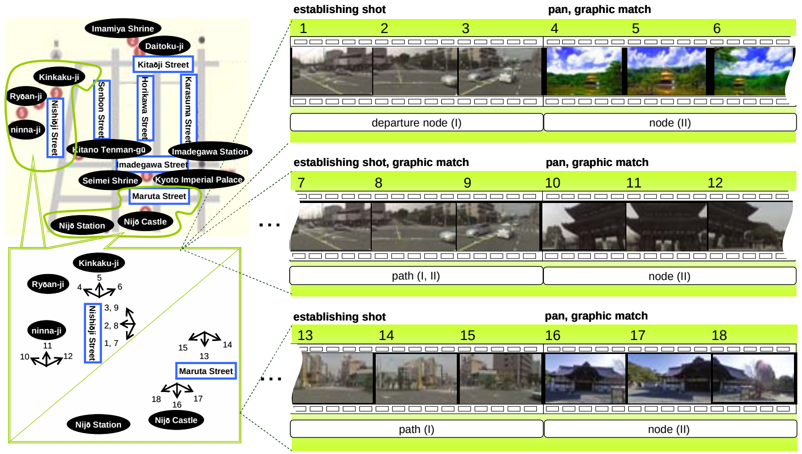


Figure 6: Example of output captures by Cinematic Street in Mixed map

- Mixed map

It is necessary for a Mixed map to show nodes that exist around paths because both paths and objects are important factors in a Mixed map. Therefore, the system calculates the nearest paths from each node. Then, the system shows them in every group based on the path that the system acquired.

First, a user selects a departure node.

I. The path of a group including a departure node is shown using an "establishing shot." shown in No. 1~3 in Figure. 6.

II. The node of a same group is shown using "pan" and "graphic match" as shown in No. 4~6 and 10~12 in Figure. 6; it is necessary for users to recognize nodes existing in the vicinity of the path.

III. Steps I and II are repeated till the last node in a group is over as shown in No.1~12 in Figure. 6; this is because it is necessary to recognize the important path by showing the path several times.

IV. When the first group is finished, the next group is shown as shown in No.13~18 in Figure. 6.

4.2 Application of Dramatic Impact by Relation among Geographical Objects

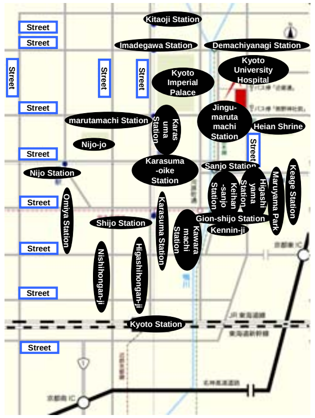
It is necessary to naturally show the turning points of geographical objects because paths and nodes are different factors. Accordingly, we propose the method for representing among geographical objects. As discussed in Section 4.1, there are various methods for representing connecting shots in a film. In our research, we treat a shot as a movement of Street View. In Section 4.1, we provide five examples of transactions, but we utilize four of these five transactions and do not employ "iris-in/iris-out," because Street View cannot recognize objects

Paths and nodes clearly show the differences in the factors by utilizing 'fade-in' in each shot line because we want to depict the passage of time and shift in location. For nodes with equivalent relations, the system shows that a change is small by utilizing the "dissolve" effect at each turning point; this is because we want to depict a smooth change of the scene. For nodes without equivalent relations, the system quickly shows a change using the "wipe" effect; this is because no relations are to be shown among the nodes.

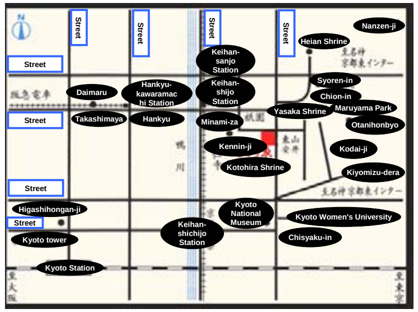
5. Discussions

We performed an experiment for extracting equivalent relations among the nodes. We utilized a part of the category structures of Wikipedia. The two maps that we used are maps of Kyoto,; we focused on the equivalent relations among "Kyoto Station" and "Keihan-Sanjo Station" on the maps, because we consider that equivalent relations among geographical objects change with the surrounding geographical objects. In Figure 7(a), we assumed that all stations such as "Shijo Station" and "Karasuma Station" have equivalent relations, because the map is drawn in such a way that many stations are included in the map. On the other hand, in Figure 7(b), we assumed that not all stations have equivalent relations because other nodes included in the map are more than the stations. We show result of experiment as follows.

As a result, in Figure 7(a), a typical category was determined as "rail station in Kyoto City" (Table 2), and all stations (seventeen stations) such as "Kyoto Station," "Keihan-Sanjo Station" and "Shijo Station" were determined to have equivalent relations in this typical category. The categories more than the threshold are considered typical categories when the difference between the former and latter category is 1.00. On the other hand, in Figure 7(b), a typical category was determined as "important cultural properties in Kyoto Prefecture," and ten tourist spots such as "Kiyomizu-dera," "Yasaka Shrine," and "Higashihongan-ji" were determined to have equivalent relations in this typical category.



(a)Modified map 1



(b) Modified map 2

Figure 7: The modified maps for experiment

Table 2: Result of experiment

Map 1		Map 2	
Category name	Category value	Category name	Category value
rail station in Kyoto City	17.00	important cultural properties in Kyoto Prefecture	10.00
rail station in Japan	16.65	designated cultural property in Japan	9.03
rail station in Kyoto Municipal Transportation Bureau	14.00	world treasures in Japan	8.00
railway in Japan	13.62	important cultural properties in Japan	7.67
…	…	…	…

In Figure 7(a), the nodes with equivalent relations are in agreement with the nodes we assumed, because the modified map shows that nodes for stations are more than other nodes. Therefore, we consider that the modified map emphasizes the rail stations. On the other hand, in Figure 7(b), we assumed that the nodes with the equivalent relations were sixteen, but the result shows ten nodes. The reason for the difference between the result and our estimation is that we estimated the equivalent relations' nodes of tourist spots and we did not know the information of all nodes. We consider that the modified map emphasizes on the nodes of important cultural properties, because in the modified map shows more nodes of important cultural properties than other nodes. Consequently, in nodes of "Kyoto Station" and "Keihan-Sanjo Station," we confirmed changing equivalent relations among the nodes by each modified maps. Thus, even if same nodes on multiple modified maps are described, it is possible to change using nodes in Cinematic Street according to each modified map because we confirmed there are differences of relations among nodes according to each modified maps

However, in this experiment, we do not utilize all the category structures of Wikipedia and do not consider hierarchical normalization. In addition, we cannot yet consider the case that the independence of the typical categories is low. Accordingly, we need to consider and improve the extraction of equivalent relations.

6. Conclusions

We proposed a system for transform a modified map into a streaming video based on the maker's intentions for creating the modified map. In this paper, we describe the extraction of equivalent relations among geographical objects in order to determine the types of each modified map on the basis of the maker's intentions for creating the a modified map. Moreover, we proposed methods for representing a streaming video based on the type of the modified map. Additionally, we discussed experiments for extracting equivalent relations among geographical objects.

In the future, we are going to examine the effectiveness of the method of showing Street View based types of each modified map. In addition, we are going to discuss other relations among the geographical objects, such as landmarks relations and inclusive relations.

7. Acknowledgments

This research was supported in part by a Grant-in-Aid for Scientific Research (B)(2) 20300039 and a Grant-in-Aid for JSPS Fellows 21.197 from the Ministry of Education, Culture, Sports, Science and Technology, Japan.

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