CO-103

PATH PLANNING USING INDOOR MAP DATA GENERATED BY THE PLAN VIEW OF EACH FLOOR

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ABSTRACT

We propose a new method for the creation of indoor map data, as well as the path planning system that connects outdoor areas with indoor areas. First, taking an example of shopping malls as a public facilities, the expression of indoor map data has been considered from the standpoint of information transmissions and searching. Next, the result is reflected and the indoor map data of Tokyo Midtown was created using the building plan view. When a building is registered in Japan, the plan view of the building has to be submitted to the Legislative Bureau, and such plans are available for a free inspection. Therefore, it makes it possible to build a database for indoor maps across the country. Reference to geographical coordinates and network data are given to the indoor map data, in order to do loose coupling on the doorway as a node. Through this process, a path planning system that seamlessly connects outdoor and indoor maps can be created.

KEYWORDS

Indoor maps, Location-Based Service, Seamless Navigation, Ubiquitous Mapping

1. INTRODUCTION

We spend much of our time living indoors in urban areas. Today, it is said that the people living in urban areas of Japan spend approximately 90%[1)] of their time indoors. In Tokyo, 57.2%[2)] of the entire land is housing land, and this percentage seems to be on a increasing. Indoor areas have become large and also very comfortable, where the demand and value are increasingly seeked after. As changes in space occur for people to live from outdoor areas to indoor areas, building and management of indoor map data should be considered essential.

Under such circumstances, location-based services[3)] that use the Global Positioning System (GPS) have dramatically become widespread. In particular, outdoor location-based services are extensively utilized thanks to the GPS function. Correction technology has also enhanced the accuracy of such services.

Although the needs of users have been reported [4)] however, indoor location-based services have not become so common. The author of this paper considers the following three reasons for this fact: (1) the indoor positioning technology is still developing, (2) indoor map data has yet to be organized, and (3) no killer application[5)] has been developed. Since GPS waves cannot be used indoors[6)], advanced research on Wi-Fi based positioning systems[7)], visible light communications[8)] and indoor Messaging Systems (IMES) [9)] have been in development, and some parts have already come into practical use.

On the other hand, only a few examples of the distribution of indoor map data, which have geographical coordinates, are now found. The author considers shopping malls and public facilities as the research target for indoor map data investigation at this time. However, it is difficult to separate public spaces and private spaces. In addition, in traditional paper maps, characters and marks expressed, scales, and directions have not been integrated. This causes improper informativity to be provided to users[10)]. From the side of the map creator, there is the concern that map creation methods could be limited because building structures and classification ownerships are complicated when it comes to indoor areas, when compared with outdoor areas.

In this research, we first compare paper-based indoor maps in order to confirm the elements which make such paper maps easier to see. By using this unique method, the indoor map data, on which the comparison results are reflected, is created. Moreover, a path planning system is experimentally produced by performing mash-up on the indoor map data created along with a map portal site.

2. PREVIOUS STUDIES

2.1 Paper based indoor maps

First of all, 50 indoor maps of France and Japan were obtained and organized according to elements that are regarded as effective for map expressions. Because there are many visitors among France and Japan, their demands of indoor maps are great. Moreover, since the 25th International Cartographic Conference will organize in Paris, we chose the indoor maps of France. These elements were classified into the

following six elements: text (notation of shop names on the map), legend (notation of shop names), pictogram, scale, direction/door way, and color. The characteristics as a map were then complemented (Table 1). Next, from the indoor maps organized according to their elements(lots of texts, size of a scale, number of a direction and colors) eight maps were selected, four each from France and Japan for a total of eight maps (Table 2). Then a questionnaire survey was conducted using 121 Japanese adult men and women. Assuming that they were shopping at a shopping center for the first time, this survey was conducted from the point of view of understandability of the map. Finally, conjoint analysis[11)] was conducted on the elements which were regarded as effective for map expressions based on the questionnaire results.

Table 1 The classification table of indoor maps

	Japan	France
text(shop name on map)	26	25
legend(shop name)	24	25
pictogram	50	50
scale	1	0
direction/door way	34	27
color(categorization)	40	39

Table 2 Indoor maps element

Japan(J)/France(F)	text/legend	scale	direction/door way	color
Takashimaya (J)	medium	large	0	lots
Tokyo Midtown(J)	lots	medium	4	lots
ISETAN(J)	medium	small	2	lots
Akasaka Biz Tower(J)	medium	medium	4	3 colors
la vallee village(F)	lots	small	0	black and white
Val d'Europe(F)	medium	medium	0	lots
Louvre(F)	short	large	4	3 colors
Galerieslafayette(F)	short	medium	2	lots

Organizing the maps according to their elements showed that almost nothing indicated the scale which is an important element for maps. Only about half of the maps had elements related to direction. The conjoint analysis showed that the elements of directions and doorways were significantly focused on as reasons for an understandable indoor map. For this reason, the indoor map created for this research should indicate directions and doorways.

Table 3 Result of conjoint analysis

text/legend		scale		direction/door way		color	
lots	0.286	large	0.264	4	0.586	lots	0.25
medium	0.125	medium	0.154	2	0.413	3 colors	-0.06
short	0.158	small	0.161	1	0.151	black and white	0.23
	(12.71%)		(5.44%)		(42.39%)		(39.46%)

A numerical value is a utility value.... It is the degree of attractiveness to the standard.

( ) is a contribution.... It is the importance of each element

2.2 Methods for the creation of indoor map data

Next, the creation methods of traditional indoor maps were investigated here. The creation methods for indoor map data can be broadly divided into two ways. One way is a method where ground surveys are performed, and the other way is a method by diverting data created by a CAD software program (CAD data) as the building drawing. There have been many ground survey studies reported on which a ground to the measurement chassis is used in combination with laser scanners, cameras, and sensors[12)]. This method using a ground to the measurement chassis has an advantage of measuring the current conditions.

However, faulty measurements could be a problem because of obstacles, and the time required for taking the measurements could be restricted because visitors stay in the indoor space during the day.

Use of CAD data also has issues where many unnecessary objects such as drawer lines exist[13)], and there is data which does not have any geographical coordinates. However, these issues can be solved technically by using the World Geodetic System Coordinate Transformation Tool[14)] developed by the Ministry of Economy, Trade and Industry. Still, a concern still exists as to the cost of locating the owners of such CAD data and even if the owners are found, there still remains the copyright issue as to whether permission for reproducing the CAD data is granted.

2.3 The seamless path planning system between outdoor and indoor maps

When we go to shopping malls or art museums, we can check in advance the detailed information of those facilities on the websites administered by the managers of such facilities. We can also use map portal sites in order to confirm the exact location where we want to go and the surrounding conditions. However, as shown by the above mentioned survey results, each of the managers provide different indoor maps, so that the expression methods also vary. The digital file formats are also different, such as regular images, PDF files, or Flash content, making such maps clumsy to use. Moreover, complicated operations are required when confirming the information about shopping malls located in the surrounding areas in terms of a geological standpoint[15)], resulting in the end user being put under a great deal of strain (Figure 1).

This problem can be solved, if an indoor map can be embedded in a map portal site as shown in Figure 2. The author considers that the installation of an accurate indoor map data onto a map portal site makes for the first step of realizing a seamless path planning system between outdoor and indoor areas.

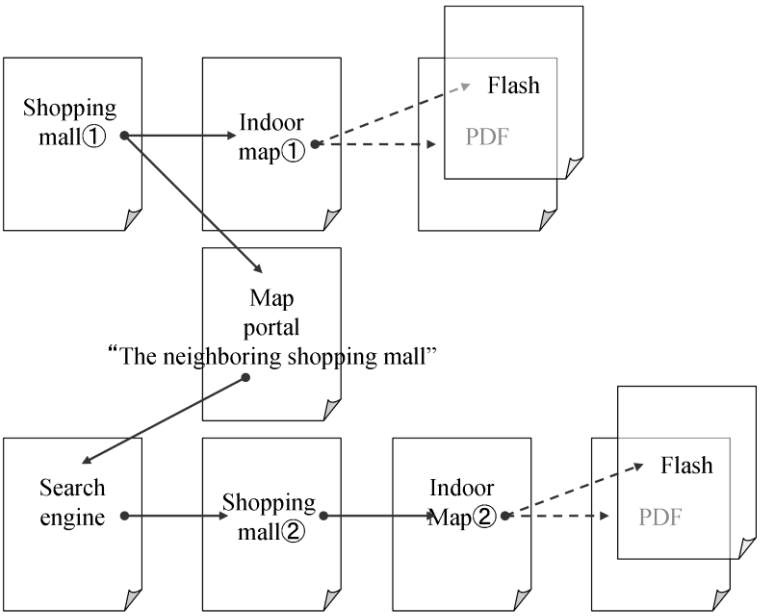

Figure 1 The present transitional state

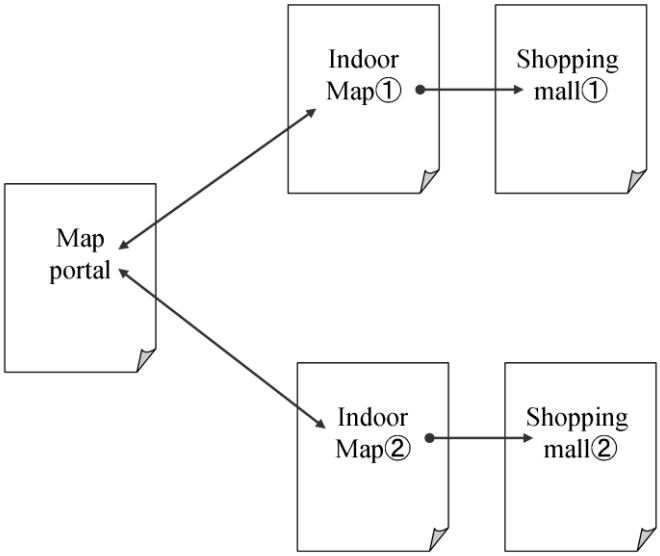

Figure 2 The transitional state from Map portal

3. CREATION OF INDOOR MAP DATA, AND IMPLEMENTATION OF A PATH PLANNING SYSTEM

3.1 The proposal of new indoor map data creation

In order to solve the issues described in the previous section, 2.2, this section proposes a new method for building an indoor map database by using a building floor plan (which is called the "plan view of each floor" in Japan) which is attached when applications are submitted to the Ministry of Justice for building registrations. In principle, the plan view of each floor is regulated to be created on a scale of one to 250, in accordance with the Real Property Registration Act (Real Property Regulations) [16]. For this reason, the accuracy level of the all plan views can be considered to be uniform. First of all, the plan views of each floor retained in the Legislative Bureau are acquired, in order to be converted from raster data into vector data. Based on the World Geodetic System coordinate Transformation Tool mentioned earlier, this conversion and geo-reference process is done by using ArcGIS[17] developed by ESRI(Environmental Systems Research Institute). Next, floor maps on paper are obtained in order to update the latest information. These floor maps are overlapped with the necessary graphic elements so that floor information is added as well as pictograms, and then the floor network data is created. However, it is at this time the doorway nodes which connect outdoor areas with indoor areas should be prepared. Through these series of steps it becomes possible to create an indoor map data from the plan views of each floor as shown in Figure 3 and Figure 4.

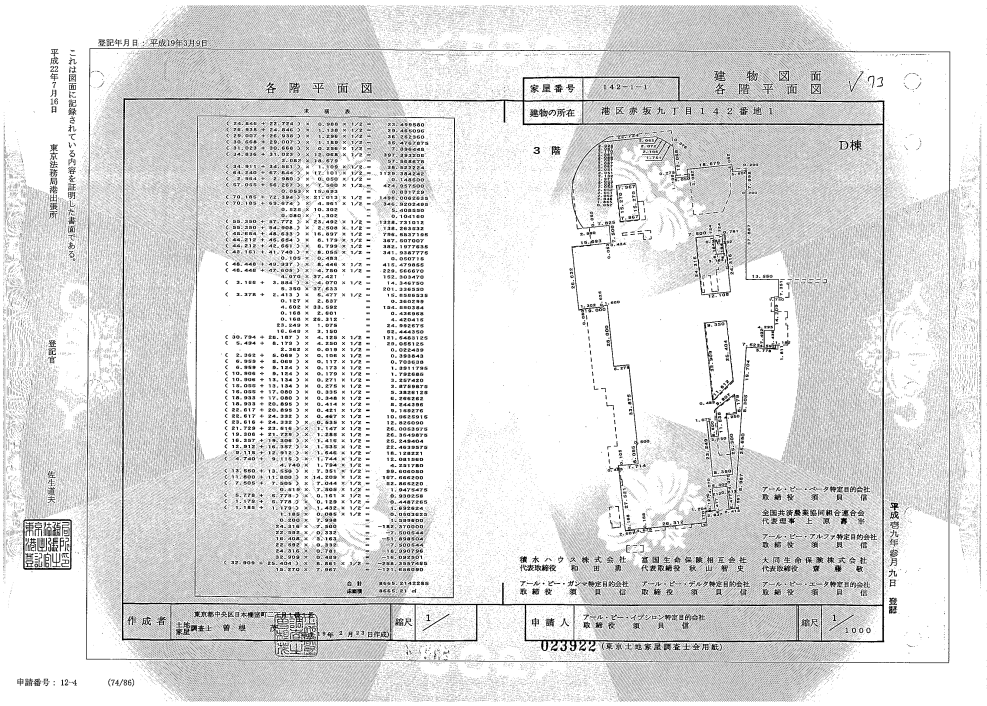

Figure 3 Paper based plan view of each floor

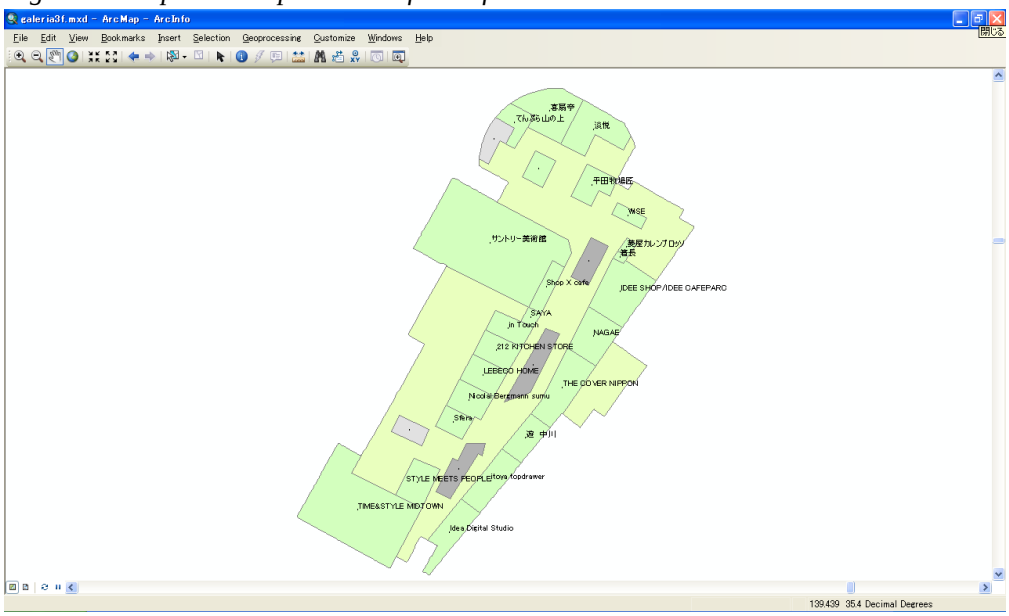

Figure 4 The created indoor map data

3.2 Implementation of path planning system

The application which makes path planning possible, in cooperation with map portal sites and indoor map data is developed experimentally in order to solve the issued described in the above section, 2.3. As to the outdoor map, Google Maps is used in order to overlap the indoor map. Overlapping the indoor map on Google Maps can indicate the elements of directions and doorways described in section 2.1 above (Figure5). A new program is developed by using the path planning API of Google Maps, which has already been released, MapServer[18], PostGIS[19] and pgRouting[20]. Although the algorithm of path planning used as the base the Dijkstra's algorithm implemented in pgRouting, transfer between floors is important in indoor spaces because routes such as stairs, escalators, and elevators need to be selectable (Figure 6) as well as barrier-free equipment, which is also a significant element. A path planning system consists of a web browser, an indoor map server, and a database server (Figure 7). The first processing creates the root of a start point and a goal point by Google Maps. Next, the root to the goal node of Google Maps and the doorway node of a building is created. As the 2nd processing, the indoor area shortest path is generated using pgRouting. Finally, the doorway nodes conduct loose coupling to connect the networks of outdoor

and indoor areas. For example, the shortest path from SHIBUYA station to a GREEN DOG shop of GALLERIA in Tokyo Midtown can be planned using this (Figure 8). As shown in Figure 9, this makes it possible to search for a seamless path planning system from outdoor areas into indoor areas.

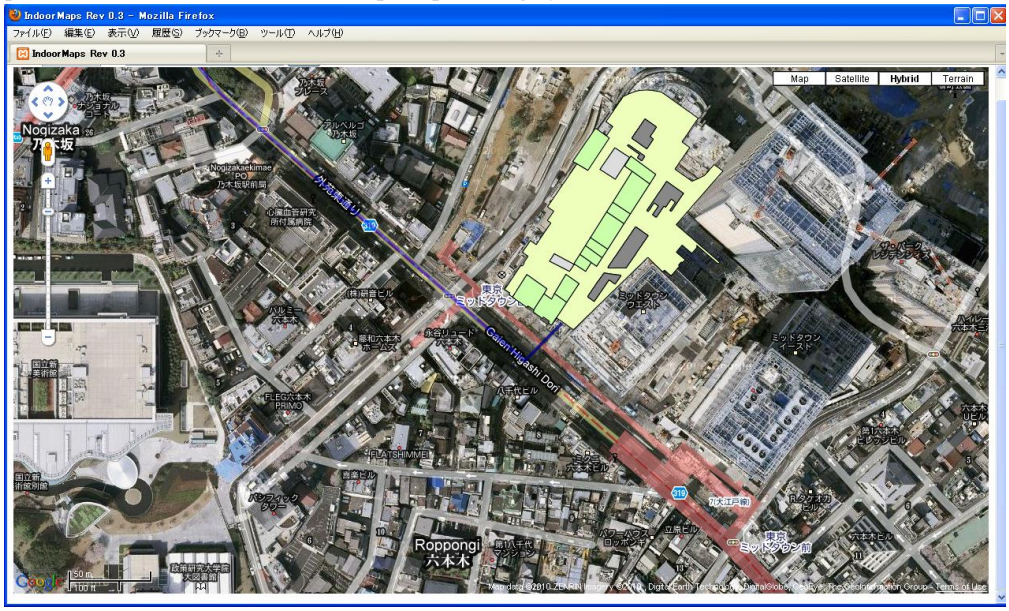

Figure 5 Overlay indoor map data on Google maps

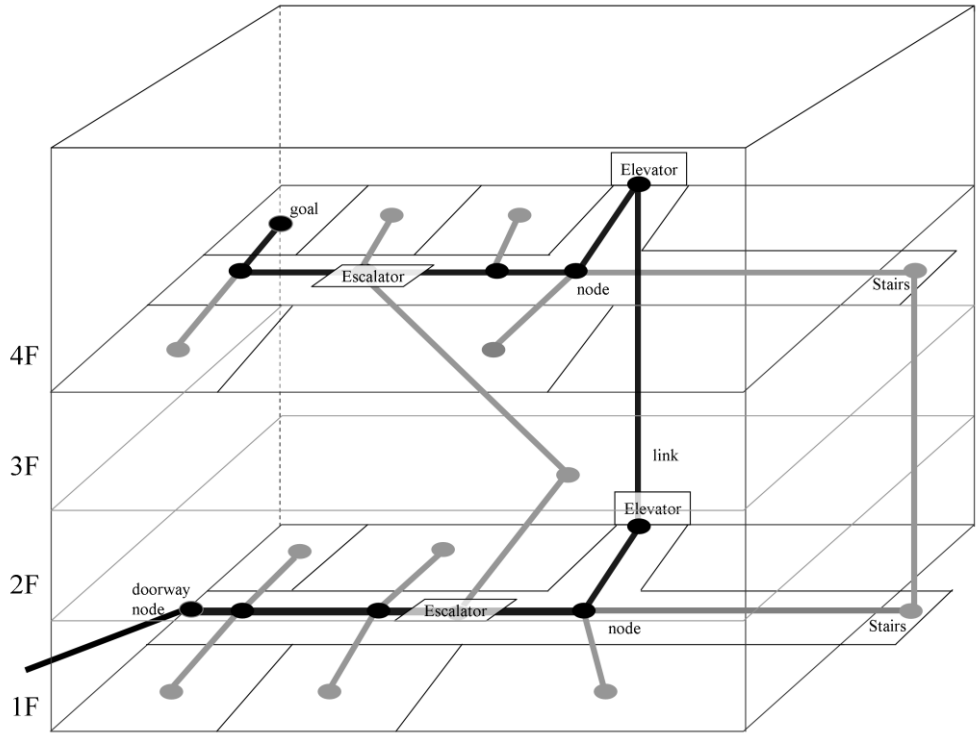

Figure 6 Floor transfer by path planning

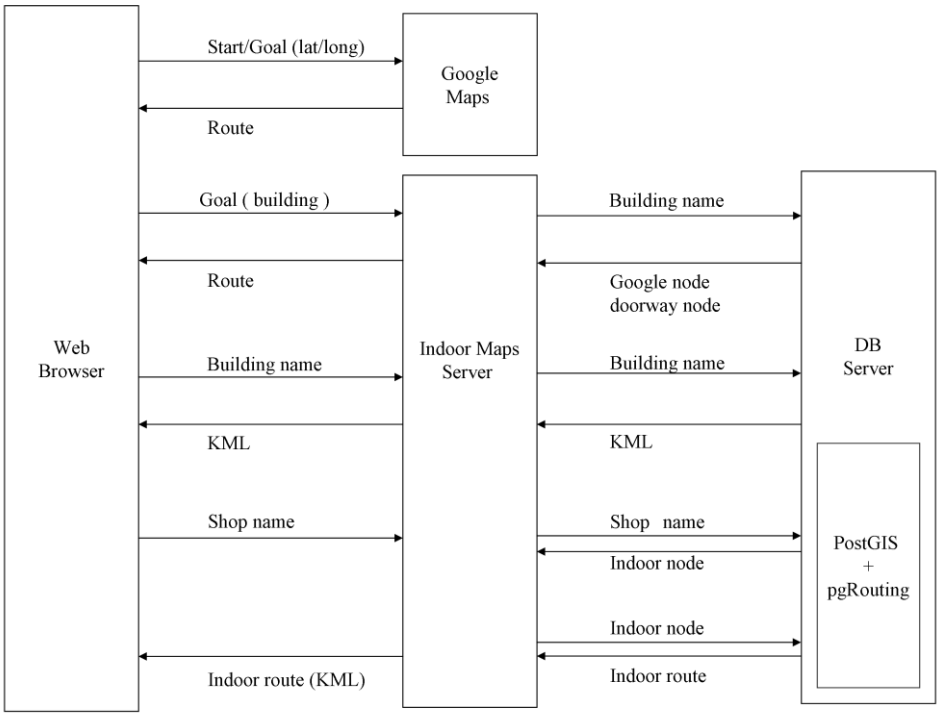

Figure 7 System architecture

Figure 8 Loose coupling on the doorway as a node

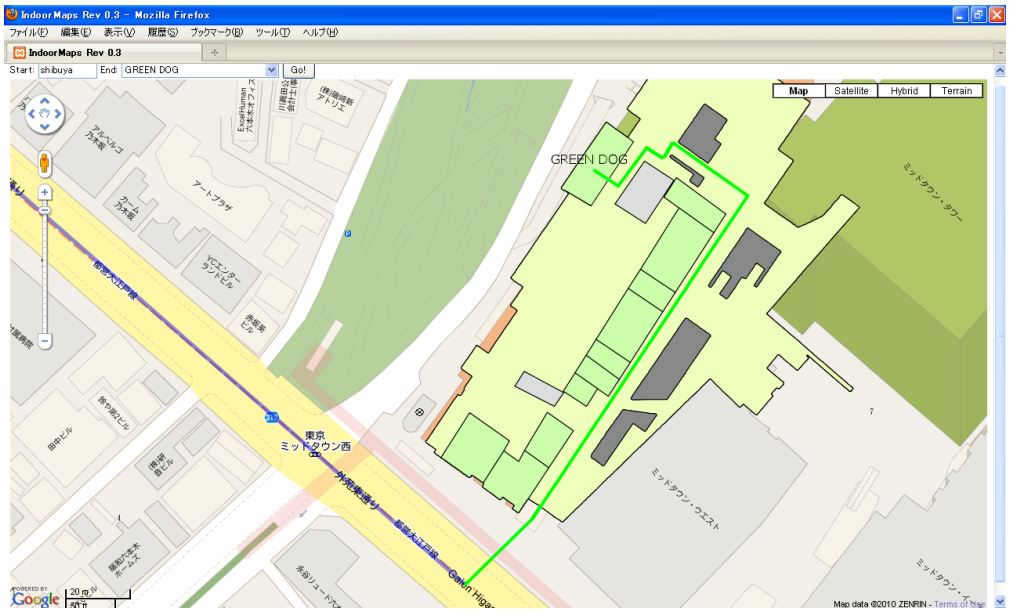

Figure 9 Seamless path planning

4. CONCLUSION

In this research, the elements of indoor maps were investigated. This investigation confirmed that the elements of directions and doorways are important for the creation of understandable indoor maps. Given that, we expressed the elements of directions and doorways by overlapping the indoor map on the map released by the map portal site. As for the methods for creating indoor map data, this research showed that use of plan views of each floor registered and retained in the Legislation Bureau made it technically-feasible to build an indoor map database of Japan. Moreover, a path planning system which connects the map portal site in outdoor areas with indoor areas was implemented as an application using indoor map data.

5. FUTURE WORK

One of the issues for practical application in the future is updating the information. For example, the idea of utilizing a SNS check-in service in order to search for a means of collecting information from users or shops. With regards to path planning, finer network data will be required in order to realize the movements from one outdoor area to another, such as train stations and parking lots.

The author will release the path planning system developed in this research, and while further verifying the utilization of this system, continue to advance research related to the interaction of indoor positioning technology in order to contribute to the further advancement of indoor ubiquitous computing.

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