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Original article

A Study of the Method for Building up 3D Right Objects

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Abstract

Recently, the demand for three-dimensional spatial information has continuously been increasing, and especially, studies of indoor/outdoor spatial information or data construction have actively been conducted. However, utilization of spatial information does not universally spread to the private sector, but it is mostly used for the government offices. Thus, this study deals with the creation of three-dimensional right objects and the technique of expression to further vitalize the private sector, three-dimensional right objects, aiming to create and express three-dimensional right spaces in a particular system or open platform more conveniently. Unlike a plane text or apartment building used in existing maps was iconified and displayed simply, this study proposes a method of extracting data from the outer border of the building by the relevant level based on the existing structured three-dimensional building, a method of providing two-dimensional right spatial objects in XML, and expressing them as three-dimensional right objects efficiently. In addition, this study will discuss a method of creating right objects in a way in which an owner who was provided with a cross section of a building involves the direct detailed right objects in additional production or reproduction to utilize three-dimensional data (right objects) produced through this study.

Keywords : 3D Expression Method, Indoor Spatial Information, 3D Right Objects, Open Platform

1. Introduction

The real world in which we live is three-dimensional, but when we look at the map through the Internet or on an App in our real lives, we search things, looking them on a simple plane. The existing three-dimensional spatial information system visually refined the outside of buildings by adding a height (depth) based on two-dimensional information or information about the videos or attributes, which is just simple city modeling (Park *et al*., 2007), so the use of that is very limited to analyze individual spatial information or check the relationship of legal rights (Lee *et al*., 2014). It might be very good if one could check all information about the building one wants to look up, such as condition of location, internal structure, relationship of registration rights and owner as well as its exterior, all at once by one log-in and one click, but currently, to check the building location, geographical conditions and legal relationships of rights of Real Estate Object A, the users themselves should log on to Google Earth or an open platform like three-dimensional spatial information open platform, V-World provided by the Ministry of Land, Infrastructure and Transport, check the outer shape of building or location information and then check its registration rights on the Internet site providing such information, additionally.

As mentioned before, one-click location information

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service was implemented, and the technology of producing three-dimensional spatial information is commercialized currently, but the costs for data construction are astronomical, so the attempt to use the technology is limited to some companies (Jeong *et al*., 2013). Therefore, this study will propose a method of creating right objects at lower costs.

A right object means a thing or right like a bond, but it is also defined as an object of the creation of profits on the civil law or according to Articles 98 and 99, Civil Code, it means an 'item.' In other words, it is a concept that covers a lot, building and facility, etc. Even if the existing system has accumulated massive right objects about three-dimensional spatial information, it has a limitation that it creates a wide variety of customer demands, using the information (Kim *et al*., 2014). In particular, for a joint building and an assembly building, because of a wide variety of relationships of rights, the limitations get more obvious in building up three-dimensional spatial information. The method of getting data (right objects) through the existing measurements has high accuracy, but a lot of time and money accompany, so the access to that from the fields that need massive data could not but be limited. As a measure to overcome these shortcomings, a method in which the users directly participate and produce data was chosen. This method in which the users accumulate right objects by producing and sharing them themselves may have lower accuracy in the beginning of the service, but with contents can be accumulated in a short period of time and it can correct the reliability as time passes. Especially, it can be used in various ways and will be used much, as a guide to the number of an apartment building or directions for a facility, in areas that do not require precision.

In order to achieve the purpose of this study smoothly, reviews of national and international literature on the method of creation and visualization of three-dimensional right objects were conducted. With the building on the ground of the target area, building information modeled by spatial information open platform (v-world) was used. For additional necessary indoor space information, data were obtained from the relevant local government, Songpa-gu Office, and the data were processed in 3DS file format based on the "Map of the Present Condition of the Building. They reproduced the actual two-dimensional drawing into 3DS by requesting the District Office for cooperation (Bae *et al*., 2015). What this study tries to present is a method of obtaining right objects more easily and quickly like this. As a means of getting right objects of the relevant building, they used a method of extracting the bottom, first based on the ground plan, created two-dimensional right objects, reconstructed them three-dimensionally, and they developed a method of expressing three-dimensional right objects on an exclusive system or open platform (e.g., V-World). When one tries to express an indoor map of a three-dimensional building based on high-precision data, if each individual draws it, not to mention the inefficiency in terms of time and economic aspect, the data quality will differ depending on the individual. As a solution to all these problems, this study added a function that allows the user to work checking the stratum of the building through the automatic extraction of the cross section of a three-dimensional building.

In addition, the three-dimensional right objects produced automatically can maximize the efficiency of data accumulation in the future, in addition to cost reduction, combined with a user participation method. However, to induce this user participation, the cross section of the building the user will register should be provided first as a precondition., if the user has to go through a process of inquiring the information in the institution that holds the cross-sectional diagram as a way of getting the cross-sectional diagram of a building, it will take much time and money, so this study extracted and utilized the cross section of the floor of the three-dimensional building with the spatial information open platform.

2. Creation of Right Objects

2.1. Acquisition of the cross section of the building

To cut the cross section of a three-dimensional building and extract it as a common polygon structure, the data about the building on V-World, an open platform of three-dimensional spatial information were used. The structure of the building on V-World expresses the form of a single structure by putting a number of triangles together with a triangular structure as a basic unit.

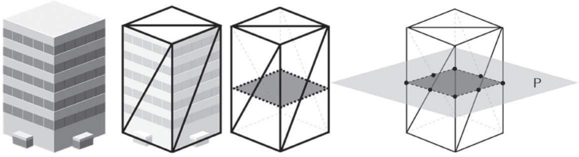


Fig. 1. The process of data processing to extract a cross-sectional diagram

A method of finding the point at which this structure and the cross section that is the space between floors of the structure overlap and cross each other was chosen. V-World data have rotation information as well as location information with the center of gravity of the globe as the starting point, which uses a coordinate system, called Earth-Center Earth-Fixed (ECEF), so the direction of the vertical vector differs all depending on the location in which a building is constructed (SpaceN, 2014).

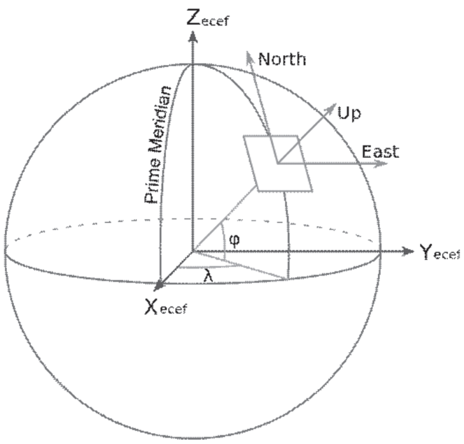


Fig. 2. The globe-based building incline

While the location is applied in vertical direction of the building from the center of the earth, the building already rotated to the latitude and longitude of the globe, so the vector of the vertical direction of the building is calculated back by making it into a plane in y-axis direction on the plane in (0, 1, 0) direction from the center of the earth and then, the desired cross section is extracted, and for the last expression, it is expressed by rotating it to longitude and latitude from the center of the earth to the original position.

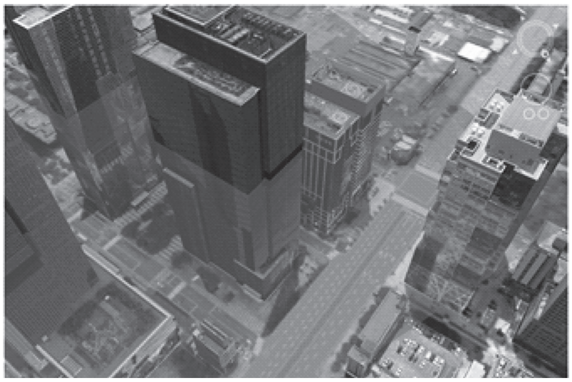


Fig. 3. Cross-sectional UI overlapping of the building based on the globe

However, the coordinates of the triangle found from the cross section is applied to a plane, the connectivity between the coordinates will be lost. In order to solve these problems, a polygon that becomes a cross section was completed by finding and connecting duplicated points based on the edge list obtained from the plane.

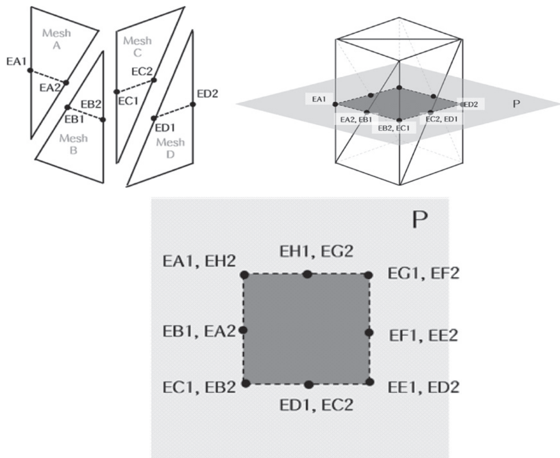


Fig. 4. The process of connecting each segment

If the last point and starting point of each segment exist at the same position, the relevant segment is in connection. Using this attribute, the last point and the first starting point are set up artificially and connecting the segment is continuously attempted, in clockwise or counterclockwise direction. Finally, if both the first starting point and last point of the segment are in connection, the segment takes a form of one closed polygon. This constituted information about the cross section, and an outer floor surface was implemented to register right objects.

2.2 Conversion of background polygon of a right objects building

Background Polygon is formed based on the edge list, by cutting the cross section of data on open platform (V-World) from three-dimension to two-dimension.

```
1   edgenum,520,pointnum,1040
2   52.817295, 5.848114, 2.485559
3   52.781250, 5.848114, 2.437500
4   52.828125, 5.848114, 2.500000
5   52.817295, 5.848114, 2.485559
6   49.209362, 5.848114, 8.082282
7   52.765625, 5.848114, 3.468750
8   48.140625, 5.848114, 9.468750
9   49.209362, 5.848114, 8.082283
10  44.028435, 5.848114, 14.802701
11  47.656250, 5.848114, 10.093750
12  42.937500, 5.848114, 16.218750
13  44.028435, 5.848114, 14.802700
14  37.308254, 5.848114, 12.692228
15  41.968750, 5.848114, 16.319727
16  35.906250, 5.848114, 11.593750
17  37.308254, 5.848114, 12.692228
18  33.964413, 5.848114, 10.096106
19  35.359375, 5.848114, 11.187500
…
```

Fig. 5. Edge List extracted

Fig. 5 is the list of lines, consisting of the sequence of XYZ–XYZ, which is the shape of the base completed, excluding y-axis, height value in the process in which two points, the minimum unit of a line into a single line, are formed and extracted, that is, Background Polygon.

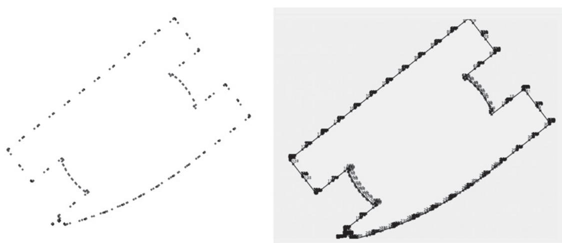


Fig. 6. Polygon rendered with points and edges

If you exclude height value from the edge list of three-dimensional plane data, load it on the memory, draw it with points and render the shape on the screen, it is displayed like Fig. 6. In the present status, there are a lot of duplicated points, the sequence is not regular, and there is no connectivity, either. In order to make a closed one polygon form out of this, two points all connected edges were compared and they were made into one complete polygon without removing the duplicated points, based on Index 0 in the edge list.

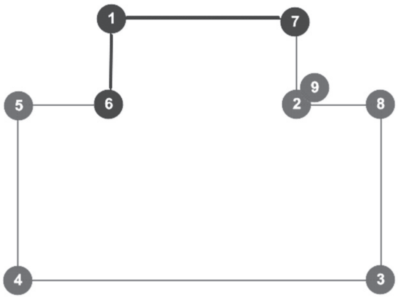


Fig. 7. The process of forming Background Polygon

Based on the line, the sequence of points did not line up like 1, 2, 3, 4, 5, 6 and 7, and the sequence of points on the actual edge list mostly entered at random. (Ex: 1, 2, 6, 4, 3, 5, 7). In order to make this list of points into edges in order such as 1-2, 2-3, 3-4, 4-5, 5-6 and 6-7, the two points on the edge were compared to the starting point and last point of all edges. As for the prerequisites for an edge list forming a polygon, under the conditions that all points are linked to two edges and that all edges consist of two points, the edge is found based on the first point.

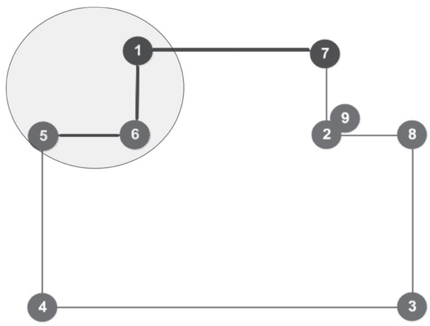


Fig. 8. The process of forming Background Polygon (2)

Point 1, the first index was taken as the starting point before forming Background Polygon. Based on Point 1, the first index, edges in different directions are found. This process is continuously repeated till the extension of each tip of these two edges meet the same point or edge to complete Background Polygon. If you look for two edges that include Point 1, the index, you can loop up Edge 1-6 and Edge 1-7, and if Point 1, the reference point is connected to the two edges, the line becomes Line (6-1-7), marked in red in Fig. 7.

In Fig. 7, if edges are inquired based on Red Line (6-1-7), the starting point and end point of the background polygon are Points 6 and 7, respectively. Based on Point 6, the Edge (1-6) and Edge (5-6) linked are found. Duplicated Point (6) is inserted in front of the first index, and Edge (1-6) with duplicated points is excluded in the next search. At this time, if you look for the edges linked from the end point of Line (6-1-7) marked in red in Fig. 7, you can look up Edge (1-7) and Edge (7-2). Duplicated Point (7) is added lastly and Edge (1-7) consisting of duplicated point is excluded in the next search. In this way, Line (6-1-7), which would be the base of Background Polygon was created for the first time. (Red line in Fig. 7)

With the same method, Background Polygon is extended by extending the link node one by one at the starting point and end point. Fig. 9 shows that Point 7, the end point of Line (5-6-1-7) forms a link, connected to Point 2.

Once the edges found are continuously extended to the end point and starting point using this method, inquiring

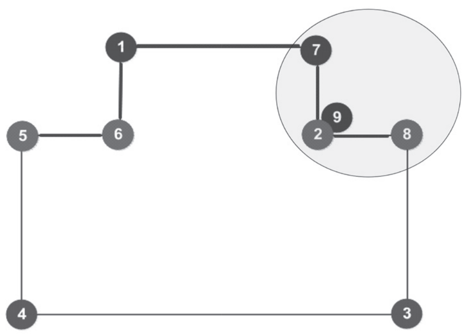


Fig. 9. The process of forming Background Polygon (3)

the edges on which points are duplicated, respectively, for Starting Point (5) and End Point (8) can find Edge (5-4) entering into the starting point in duplication and Edge (8-3) entering into the last point in duplication from the line that consists of points in the sequence of 5-6-1-7-2-8 as in Fig. 10.

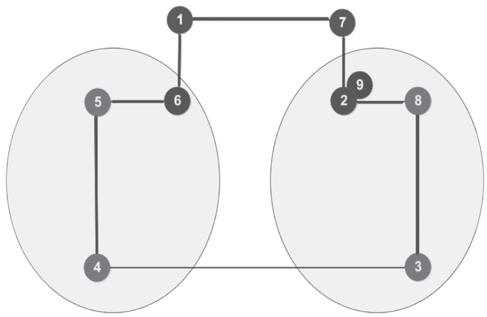


Fig. 10. The process of forming Background Polygon (4)

For a list of points in the sequence of 4-5-6-1-7-2-8, an edge connected to the starting point and end point was found. Since the edge found was overlapped with Edge (4-3) and Edge (3-4) in Fig. 11 and all edges referred to, here were used, so there is no more edge to inquire. In addition, Point 9 included in a duplicated point or edge is removed in the process of conversion to a polygon.

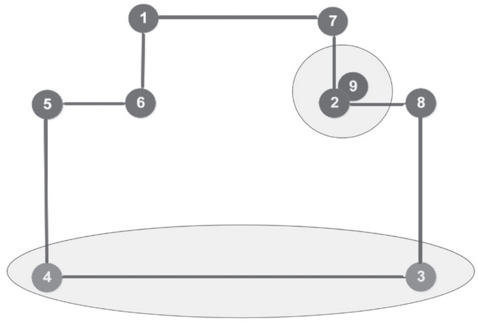


Fig. 11. The process of forming Background Polygon (5)

Based on one edge like this, by searching all other edges, connecting the starting point or last point to the starting point or end point of another edge and a number of edges were extended to a single polygon.

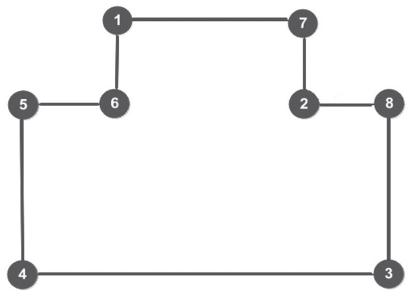


Fig. 12. The process of forming Background Polygon (6)

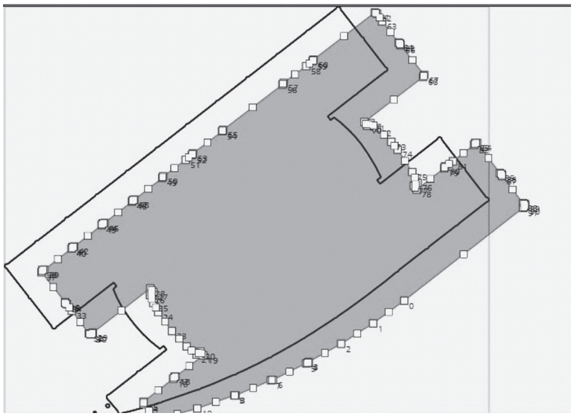


Fig. 13. The process of forming Background Polygon (7)

The object completed as a single polygon using the above technologies can be rendered as a line or polygon as in Fig. 13. The part consisting of black lines is the result of visualization as a line while it was formed as the edge list was converted to a background polygon. The part expressed in a purple shade is the result of rendering the polygon shape as it was. To look into the purple part in Fig. 13, there are countless points that form the outline of the polygon. For example, if the line is extended almost at the same angle, like the side of the upper-left corner, a method of connecting them could be attempted to merge them into one, and the polygon shape could be simplified with a method of removing or merging the duplicated points at the very similar place. The result of this simplification can be seen in Fig. 14.

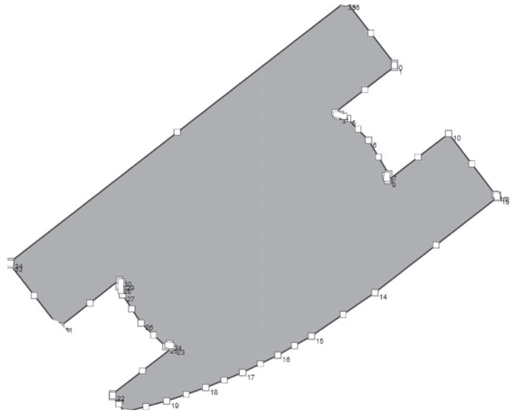


Fig. 14. The result of production of a simple polygon

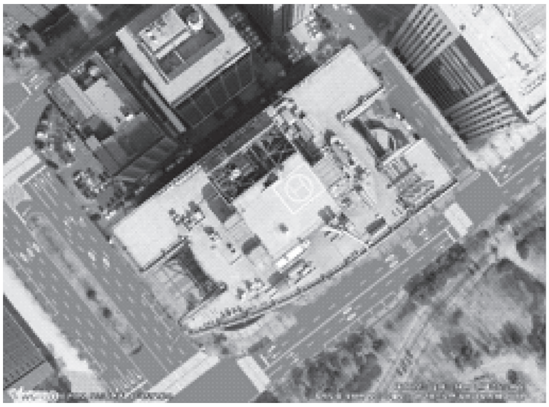


Fig. 15. The target building viewed from above

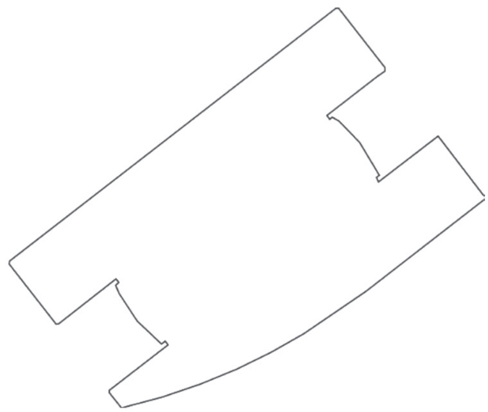


Fig. 16. The result of production of a simple polygon

3. Creating and Editing Right Objects

3.1 Creating right objects

Based on the technology above, the outlines of a random building in Fig. 15 were created as a background polygon by cutting the cross section, using a data API provided by the open platform. In this background polygon, the user should produce indoor right objects once again. As for the method, drag and rotation techniques often used in the process of editing pictures on smart phones were used to increase user accessibility. The user drags a polygon in a desired shape to the area to which an indoor right object is assigned, on the created background polygon. In the example, a quadrangle polygon was used.

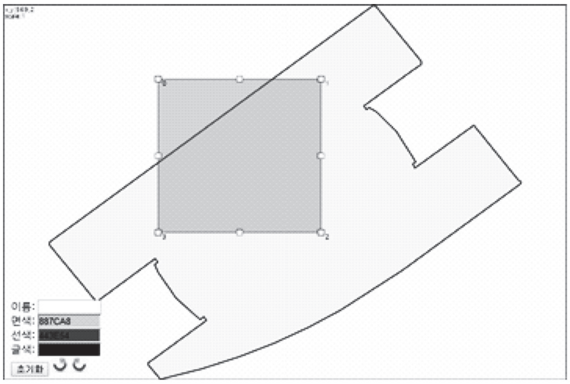


Fig. 17. Drawing a polygon quadrangle

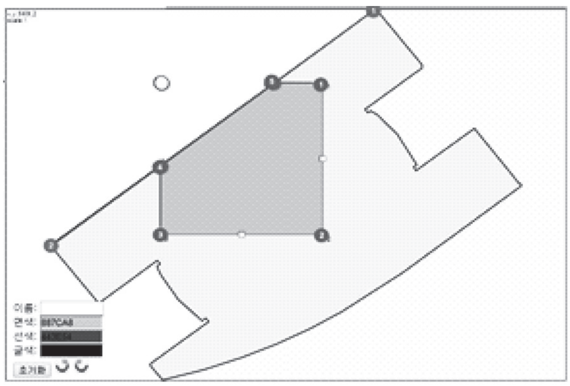


Fig. 18. Exclusion of deviating points

Once a polygon is placed in a position a user wants, the indoor right object the user wants is expressed, using rotation or zoom in/out function. At this time, cut only the inner right objects which come under the interior of the indoor right object polygon that consist of red points and the background polygon.

Enter name (attribute information) of the right object in a polygon additionally.

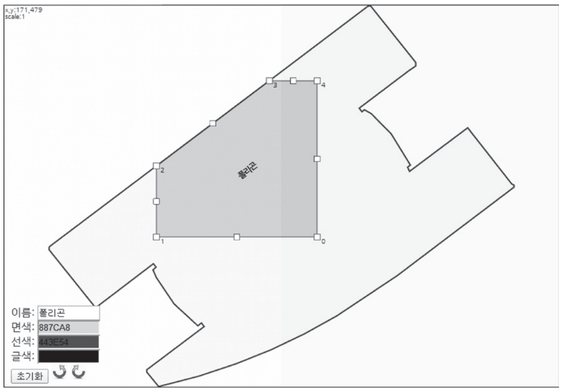


Fig. 19. Labeling of objects

Objects entered subsequently were calculated, referring to the object already created and the background polygon together, and objects were continuously created so that indoor right objects were created as follows.

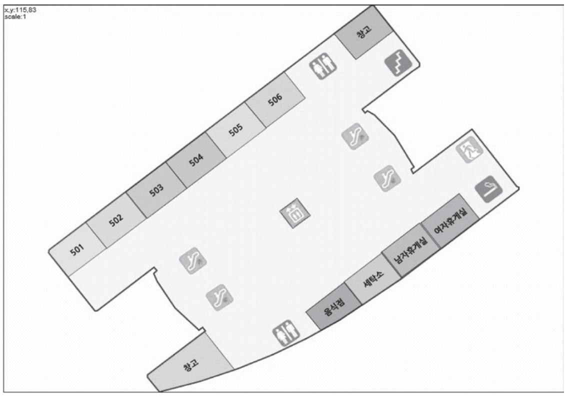


Fig. 20. An indoor right object rendered

3.2 Structure of two-dimensional right objects

Indoor right object data produced by adding attribute information to two-dimensional polygon data were made in XML (Extensible Markup Language) and converted to three-dimensional right object data. The XML of the

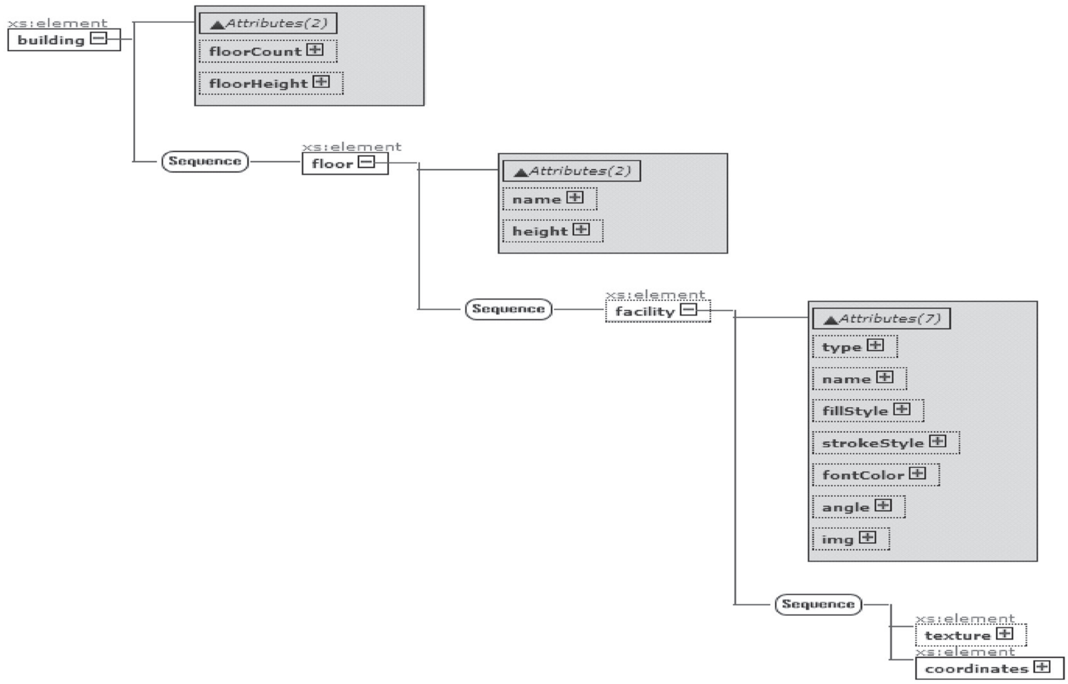


Fig. 21. Structure of right object XML

indoor right objects was composed of Building Tag to store information about the building only with the minimum elements, for three-dimensional expression, Floor Tag that serves as a frame of the relevant floor and Facility Tag that forms the inside of the relevant floor.

Building Tag: This is a tag storing the information about the building to which the floor belongs, and the details are like the table below.

Table 1. Composition of the building tag of a right object

Tag	Type	Comment
floorCount	int	floor count of building
floorHeight	float	height of a floor of building
floor	Object	a floor object

Table 2. Composition of the building tag of a right object

Tag	Type	Comment
name	int	floor name
height	string	floor height
facility	Object	object

Floor Tag: This is a tag storing information about the floor to which the facilities belong, and the details are like the table below.

Facility Tag: This is a tag storing information about the object to which the facilities belong, and the details are like the table below.

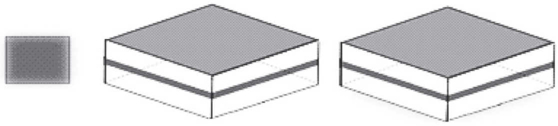
Table 3. Composition of the facility tag of a right object

Tag	Type	Comment
type	int	-1 : floor 0 : right object 1 : object
name	string	name
fillStyle	string	face color rgba (r,g,b,a)
storkeStyle	string	line color rgba (r,g,b,a)
fontColor	string	label color rgba (r,g,b,a)
angle	int	label angle 0~359
img	url	object icon url
texture	url	floor texture url (shadow)

To bring the stereoscopic visibility into relief further during the three-dimensional schematization from two-dimensional XML, the shadow option was added in two-dimensional plane rendering in HTML5 and applied to the bottom and top of a three-dimensional object. The shadow option was expressed by setting a value before rendering on the screen in CANVAS Tag of HTML5 after converting two-dimensional plane data to XML.

```
var ctx = canvas.getContext('2d');
ctx.shadowBlur=20;
ctx.shadowColor="black";
drawFrame();
ctx.shadowBlur=0;
```

Fig. 22. The code to add the shadow option (HTML5)



(a) (b) (c)

(a) Two-dimensional Rectangle Object
(b) Three-dimensional Object
(c) Three-dimensional Object + Shadow Effect

Fig. 23. Three-dimensional expression method of a right object

4. Conclusion

Icons were arranged for facilities necessary for common use in a building, such as bathroom, escalator, elevator, emergency exit and smoking area, so that you can get the view at a glance by three-dimensional symbols by directly loading a three-dimensional symbol (3DS) file with the direction of position the coordinate points to as an axis from the center of the earth, and rotating them to a specified angle on a two-dimensional plane clockwise from the axis. The results of the final completion by doing this can be seen in Fig. 24.

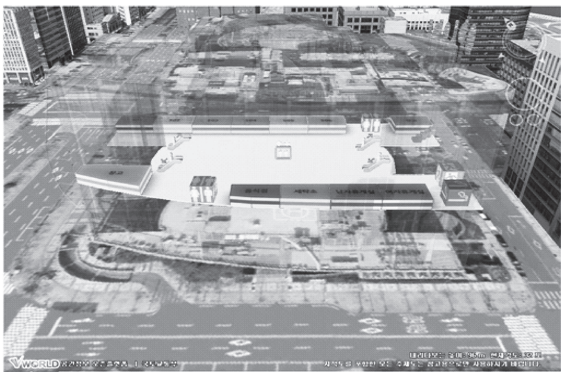


Fig. 24. A right object displayed on a three-dimensional map

This study used a method of reconstituting the shapes of a right object by recognizing automatically the outer line of the background polygon or performing a calculation with the shape of another right object, if a user registers an object in a quadrangle or circle usually and finds an approximate size, considering that the user is not an expert, as a prerequisite for the user's registration of a direct right object, so as to create a three-dimensional right object. It was designed so that the locations of access routes to the relevant floor, such as elevator, escalator and stairs, publicly used in a building could be entered additionally, but to register them in the simplest way, three-dimensional symbols were arranged. This study developed the function of an automatic conversion to a three-dimensional map in order to produce a quality visualization effect based on the data entered through the simplest way. To increase the quality of visualization, the cost for the performance of the equipment consumed was reduced by replacing public amenities such as elevator, bathroom and stairs by three-dimensional symbols and including right objects in the floor texture by creating a shadow effect automatically. Moreover, data on two-dimensional right objects are managed in an XML form, so it is expected that they can be used in more places.

Acknowledgments

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