

Indoor Routing in Three Dimensional Spaces

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Abstract — Spatial data is the data that stores geographic data types. This data is often used on systems that use data related to the territory of a region, such as the routing system or navigation system. The routing system has been implemented on the outdoor routing, and over the times began to be developed in the indoor routing. There are significant differences that make indoor routing is more complex than outdoor routing, which is the outdoor routing only implements two-dimensional spaces routing, while at the indoor routing allows the routing of the three-dimensional spaces that represent high rise building. This paper will be concern to the concept of how indoor routing for navigation system will be build. In the case of indoor routing, using the three-dimensional spaces will identify an object accurately by represent the data to undirected graph with three-dimensional attributes where x and y are the coordinates of a point, and z represents height level of the points. The shortest path routing algorithm can be implemented after the three dimensional spaces structure was built in order to inform the users about the shortest route between two points in indoor spaces.

Keywords — spatial; indoor routing; three dimensional spaces; graph programming.

I. Introduction

In recent years, a navigation system or outdoor routing systems like Google Maps is become very beneficial, especially in people who travel often without knowing the direction to reach their destination places^[4]. Later, this navigation system is also implemented in a smaller area, like on indoor spaces mapping inside a building. With the idea of indoor routing system, someone will be facilitated in finding the target location^[7]. Indoor routing application is pretty much grown abroad for certain places such as malls, airports, offices, etc. However in Indonesia, the majority still use manual mapping system by displaying a room map plan in the building. By using this indoor routing system, it would be easier for the users to find the exact room, for a simple example, finding Pizza Hut Restaurant in a super mall.

There are significant differences that make indoor routing more complex than outdoor routing, which is the outdoor routing generally implemented in two-dimensional spaces, while at the indoor routing allows the routing of the three-dimensional spaces that represent high rise building^[7]. This is a challenge in constructing indoor routing system, how to represent indoor spaces in a building? A building may have numbers of rooms and numbers of corridors. Each room allows for a variety of doors that connect the room with another spaces. And the building can be a multi-level building that has stairs, lifts, or elevators to move from one level to another. The entire spaces must have identified by labels as well as connectivity between the spaces. Three dimensional spaces could be a solution to build the indoor routing system. This method will identify an object accurately by storing geographic data that are represented to undirected graph form which has three-dimensional attributes x , y , and z , where x and y are the coordinates of a point, and z represents the height level of the points^[2].

II. Indoor Routing Data Structure

The major challenge in indoor routing system is how to construct the data structure that represent the indoor spaces. Look at the illustration in Figure 1.

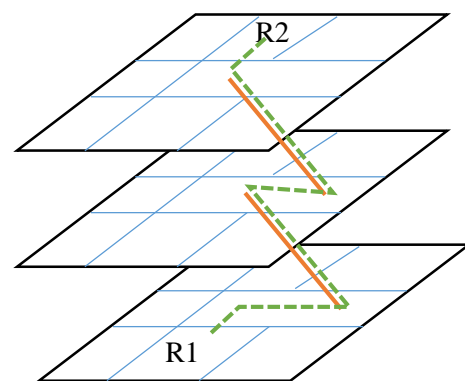


Figure 1. Illustration of distance between two rooms

By looking at the illustration, it would be easy for human to find out the path to go from R1 to R2. But for the computer, it needs the exact data structure that can represent the rooms, the corridors, and also the stairs. The undirected graph can be implemented. And in Table 1, it is the idea of how

to represent the indoor routing system using the undirected graph.

Table 1. The concept of indoor spaces modeling

Domain Concept	Modeling Concept
Room	A node
Door	An edge
Corridor	One or more nodes with one or more edges
Stair	One or more nodes with one or more edges
Elevator	One node with several edges
Pathway	One or more nodes with several edges

Next illustration in Figure 2 and Figure 3 will explain the undirected graph form for indoor routing system.

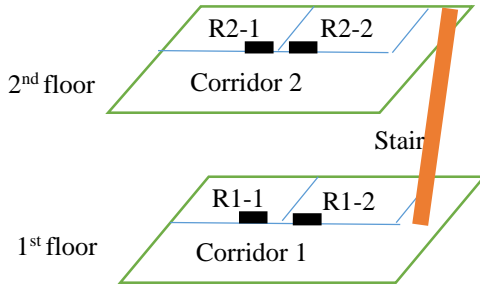


Figure 2a. Building Map Form Illustration

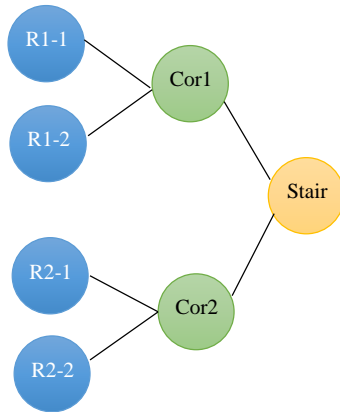


Figure 2b. Directed Graph Form Illustration

As shown above, the graph structure has been build. And the next step to do is give the three-dimensional spaces attribute to each room node. Each room node will have attribute x and y as its coordinate or location, and attribute z as its height level. To determine the main position $\{0, 0\}$, we can assume that the building is a two-dimensional geometric shape from above, and we can use the calculation formula of two-dimensional weight point:

$$x_0 = \frac{A_1x_1 + A_2x_2 + A_3x_3 + \dots + A_nx_n}{A_1 + A_2 + A_3 + A_4 + \dots + A_n} = \frac{\sum_{i=1}^n A_i x_i}{\sum_{i=1}^n A_i}$$

$$y_0 = \frac{A_1y_1 + A_2y_2 + A_3y_3 + \dots + A_ny_n}{A_1 + A_2 + A_3 + A_4 + \dots + A_n} = \frac{\sum_{i=1}^n A_i y_i}{\sum_{i=1}^n A_i} \quad (1)$$

If we have determine the location of main point $\{0, 0\}$, we can add the three-dimensional attributes for the nodes by calculating the exact distance in meters.

In this research, the indoor routing will be apply not only for one building, but for several buildings. For example, the buildings of School of Computing Telkom University, Bandung, Indonesia. There are about five buildings in one are. So we can assume that the area as two-dimensional shape to determine the main position $\{0, 0\}$.

III. Shortest Path Algorithm

The routing system method by applying two-dimensional spaces should also applicable to three-dimensional spaces. The system will be able to receive two inputs, the first input is the location of starting point and the second input is the destination point. The system would then output the shortest route from those points. Figure 3 will inform the general process of the indoor routing system.

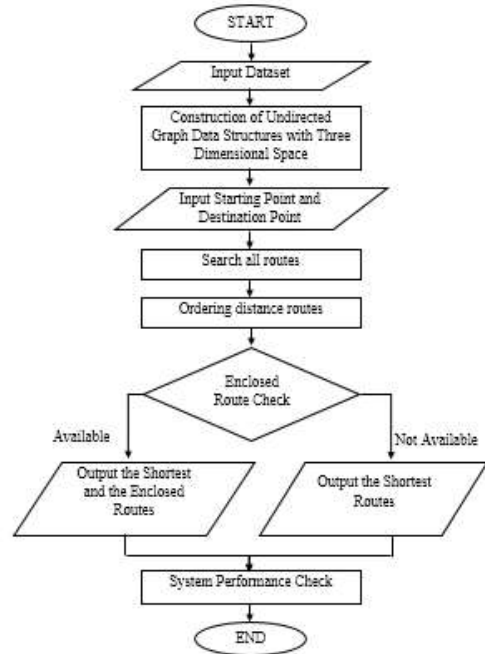


Figure 3 General Process of Indoor Routing System

According to the published paper by Kairanbay Magzhan and Hajar Mat Jani about A Review and Evaluation of Shortest Path Algorithm, here in Table 2 is the illustration of time complexity of Djikstra, Bellman-Ford, and Floyd-Warshall Algorithm where n represents the total number of nodes, and m is the total number of edges.

Table 2. Illustration of Djikstra, Bellman-Ford, and Floyd-Warshall Algorithm Time Complexity

Algorithm	Time Complexity
Dijkstra	$n^2 + m$
Bellman-Ford	n^3
Floyd-Warshall	nm

One of Djikstra and Floyd-Warshall Algorithm could be the best algorithm to improve the system. We could compare both algorithm to find out which one is the best.

To improve the user's satisfaction, there is an additional option of route in the system, which is the enclosed route. User can choose that route if it heavy raining, or the outside temperature is too hot.

IV. Conclusion

This paper offering the concept of indoor routing system using three-dimensional spaces, which is a navigation system for indoor spaces that can serve the shortest route. It also offering an additional route, which is the enclosed route to move from one building to another. It needs no GPS to perform the directions. It is a useful system that can be implemented in schools, universities, airport, shopping centers, and other public interesting points. Djikstra Algorithm or Floyd-Warshall Algorithm may be the best algorithm implemented in the system, it depends on the undirected graph indoor data structure.

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