OptiRoute: Interactive Maps for Wayfinding in a Complex Environment

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***Abstract*—Visitors to amusement parks use mobile map applications to decide where to go and to plan efficient routes. Such applications are especially helpful when visitors wish to avoid re-tracking their steps or visiting regions in the park several times. Visitors have limited time in the park, which typically covers a very large area, and the attractions have waiting times of varying duration. Time management is therefore important. In this paper, we propose a new visualization technique to support such route decision making, using an interactive environment. The main contribution of our system, OptiRoute, is the automatic computation of an optimal route between selected attractions as well as its effective visualization, which focuses on reducing visual clutter. This is achieved by improving the branch and bound route-finding algorithm, and introducing an intersection minimization algorithm for route representation. We demonstrate the feasibility of our approach through a case study of Tokyo Disneyland, in addition to a user study.**

***Index Terms*—Visualization, Maps, Route finding, Wayfinding**

I. Introduction

An amusement park is a popular family outing. However, the large size of amusement parks such as Tokyo Disneyland makes it challenging for visitors to manage their limited time while visiting all the attractions and facilities they wish to see. Visitors to the park like to ride as many attractions as possible, while avoiding long waiting times. In addition, they typically want breaks between attractions to visit the other park facilities, such as food stands, shops, restrooms and cafes. Several visualizations have been studied to help users in effective map navigation ([2], [3], [4]). A good visualization needs to consider several factors, such as deciding which information needs to be displayed and which information can be suppressed because it is not important to the users. Our goal is to develop a user-friendly visualization that supports users in their wayfinding.

This paper presents a novel system called OptiRoute which optimizes and visualizes routes between points of interest. The aim is to improve visitors wayfinding in the park, while taking into account shops and restaurants located on the path between attractions. The method used in OptiRoute includes a route optimization algorithm, as well as an effective visualization which reduces visual clutter and the intersections of these routes. This is difficult to achieve with only the static map that many parks (including Tokyo Disneyland) currently provide. A dynamic map, on the other hand, offers more sophisticated visualization features which can adapt according to visitors' personal preferences.

The visualization is a 2D map of Tokyo Disneyland, displaying all paths, attractions and all other facilities located within the park limits. However, there are difficulties in creating a good visualization, since drawing paths between different attractions at the same time could lead to intersections and path overlaps. In our approach, we try to reduce these intersections and overlaps in order to create an effective visualization.

II. Methodology

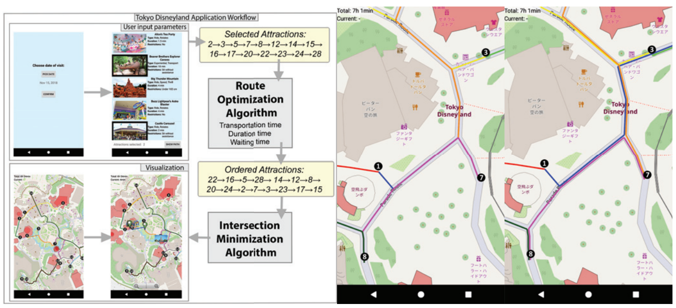
Our technique aims to provide visitors with an intuitive and interactive map to support their route and time management. The map is designed to select and display essential information to the users at appropriate time points. Users can take advantage of the features of OptiRoute by selecting a date and the attractions they wish to visit. This information is passed to the *Route Optimization Algorithm*, which calculates the optimal order of the attractions using an improved branch and bound route-finding algorithm. The most optimal routes are then visualized using the *Intersection Minimization Algorithm* by reducing the possible intersections. Interaction with the visualization is also possible, with an animated connection between two attractions shown. In addition, the visualization shows all shops and restaurants located on the route. The workflow can be seen in Fig. 1(a).

A. Route Network Creation

We use a graph as the primary data structure in OptiRoute to represent underlying route connectivity between attractions. The route information is formulated as a single connected graph, to allow for the calculation of the shortest path between two attractions. The coordinates of each attraction are taken from OpenStreetMap [1] and the minimum pairwise paths and distances are calculated using the Dijkstra Algorithm. We only use the precalculated shortest paths for the route computation in order to keep our graph sparse enough for real-time computation.

B. Route Visualization

In our visualization, we represent the layout of the optimal routes by minimizing the overlaps and intersections between these routes – this is needed because some of the paths can be traversed more than once. This could lead to numerous overlaps if we draw line segments on the same position multiple times. As shown in Fig. 1(b), if two lines overlap with each other it is hard for the visitors to identify the appropriate direction to follow. To solve this problem, the paths are offset in a way that the intersections and the overlaps with other paths are minimized. The algorithm (called the *Intersection Minimization Algorithm*) considers all coordinates and identifies the intersections on a certain line and how are they positioned. It calculates a path with minimal intersections with the lines and determines where the new line should be drawn, using the least amount of crossing lines. There are two possibilities – either drawn on the left or on the right side of the existing lines.



(a) (b) (c)

Fig. 1. Examples from OptiRoute, which includes (a) a scenario diagram, (b) a result without path offset, and (c) the result with a path offset and the intersection minimization algorithm.

III. Results

Figs. 1(c) shows the result after selecting 15 attractions from Tokyo Disneyland. The numbers indicate attractions and the colors depict the route between a pair of attractions. For example, no. 7 is *Mark Twain Riverboat* and no. 8 is *Haunted Mansion*, and the pink route between them is the shortest path leading from 7 to 8. It is clear that in Fig. 1(b) a user cannot see where the pink route goes since it is hidden under the green route.

We evaluated the effectiveness of our approach by a qualitative evaluation in the form of an interview. Six participants with ages between 20 and 60 and with different educational backgrounds were interviewed in two stages. First, we asked the participants to perform several common tasks using maps without the offset technique (Fig. 1(b)). Second, the same dataset was used, but with the offset technique (Fig. 1(c)). The participants were not told which one of the two visualizations uses the algorithm so that their answers were not biased.

We asked the participants to indicate for which visualization the routes were most visible and could be tracked most easily. All participants were in favour of the visualization using our *Intersection Minimization*. They confirmed that it was easier to follow and understand since all routes were visible and had fewer intersections and overlaps. Three participants could not suggest a more intuitive way to visualize the routes. The other three suggested that the route between a pair of attractions should only be displayed when a user clicks on the desired attraction. Another suggestion was to add arrows to the routes, so that even when the user zooms into the route, the walking direction would be obvious. Furthermore, one of the participants suggested it would be more intuitive if the map could rotate so the visitor could get a better orientation, such as egocentric maps.

All participants found the animation helpful since it highlights the current route. They also found the images of the attractions useful for supporting the users in locating the attractions in the park, and the display of points of interest helpful for visitors finding their way around the park. OptiRoute will suggest restaurants or shops they might like to visit at the end of the day or if they decide to take a break. All participants agreed that an interactive map will save them time and will helpfully guide them through the park. In addition, it would give them a preliminary overview of the routes and the expected total time in advance.

IV. Conclusion and Future Research Direction

This paper presents an interactive route visualization technique, called OptiRoute, used on a case study of Tokyo Disneyland. Our *Intersection Minimization Algorithm* uses a greedy approach to minimize the route intersections, and an offset technique to produce an occlusion-free visualization. The proposed technique has been demonstrated to be useful in supporting the users with planning their trip by providing a route visualization which is legible and easy to follow. It can be applied not only to amusement parks but also to other situations that require similar efficient route finding.

OptiRoute currently concentrates on the performance of the optimization and the visualization of the routes. Future work will include investigating various human factors such as taking into account different walking speeds of different types of visitors and scheduled breaks. For example, every two hours, the system could plan a visit to nearby restaurants, cafes, or shops, benefiting both the owners of the parks and the visitors. It might be useful to create a balance within a series of attractions by type, for example by alternating exciting attractions with relaxing ones. Additional implementation features could include incorporating a more sophisticated user interface and linking the application with a mobile compass and a GPS system.

References

[1] Open street map. https://www.openstreetmap.org/.

[2] M. A. Bekos, M. Kaufmann, K. Potika, and A. Symvonis. Line crossing minimization on metro maps. In S.-H. Hong, T. Nishizeki, and W. Quan, editors, *Graph Drawing*, pages 231–242, Berlin, Heidelberg, 2008. Springer Berlin Heidelberg.

[3] M. Benkert, M. Nöllenburg, T. Uno, and A. Wolff. Minimizing intra-edge crossings in wiring diagrams and public transportation maps. In M. Kaufmann and D. Wagner, editors, *Graph Drawing*, pages 270–281, Berlin, Heidelberg, 2007. Springer Berlin Heidelberg.

[4] S.-H. Hong, D. Merrick, and H. A. D. do Nascimento. The metro map layout problem. In *InVis.au*, 2004.