2008 Second International Symposium on Universal Communication

A Tourist Route Search System Based on Web Information and the Visibility of Scenic Sights

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Abstract

With the growth of massive information on the Web, information recommendation and filtering techniques have been studied intensively. Traditional route search systems, which can be considered one of information recommendation systems, usually calculate the shortest path in terms of time or distance. Recently, route search systems for more general purposes have become an important research topic. In this paper we propose an efficient tourist route search system which not only recommends the path simply connecting several tourist spots, but also recommends the path with beautiful scenic sights. We focus on the visibility of scenic sights between one tourist spot and another, which is an important factor for choosing a driving route, but has not been considered in traditional tourist navigation systems. To automatically retrieve tourist spots, we propose a personalized tourist spot recommendation technique using the Web information. To find a route with attractive scenery, scores for paths based on the visibility of scenic sights are calculated and utilized. We tested the effectiveness of the proposed system by using a prototype of the system.

1. Introduction

In recent years, information recommendation and filtering techniques for user preferences have become an important research topic and have been studied intensively. Extracting and presenting user-desired information from the Web is crucial for such techniques. So far, many applications have been developed, such as analyzing Web pages and filtering relevant Web news to readers who may be interested in it.

On the other hand, research on car navigation systems is actively conducted in the fields of Geographic Information Systems (GIS) and Intelligent Transport Systems (ITS). In most of navigation systems, a shortest path search and traffic jam avoidance have been considered main research targets. Currently, advanced tourist route search systems in accordance with Web information and user preferences become an important topic for car navigation systems.

In this paper, we propose an advanced route search system which integrates the Web information into route navigation systems. Furthermore, we consider the visibility of scenery along a route, which is an important factor to decide an actual driving route, i.e., our system not only recommends the path connecting several famous spots, but also recommends the path which has beautiful scenery. To achieve this, the famous spots are extracted from the Web by analyzing Web pages, and the routes with attractive scenic sights between spots are highly ranked by calculating the visibility of scenic sights. We informally define *scenic sights* mentioned in this paper as “landscapes that can be enjoyed as a distant view”, such as Mt. Fuji, Eiffel Tower, Tian’an Gate, and so on. The proposed system has two features: (i) a personalized tourist spot recommendation technique using the Web information dependent on users’ pref-

978-0-7695-3433-6/08 $25.00 © 2008 IEEE
DOI 10.1109/ISUC.2008.19

erences, and (ii) a route search technique based on the visibility of scenic sights from a path.

The rest of this paper is structured as follows. Section 2 reviews the related work. In Section 3, the overview of the proposed system is presented. Section 4 describes the recommendation of spots and scenic sights, and Section 5 gives the details of route recommendation. Section 6 reports the experimental results and their evaluations. In Section 7, an implemented prototype of the proposed system is shown. Finally, we conclude this paper and discuss the future work in Section 8.

2. Related work

Information recommendation based on personal interests is currently an active research area. Jameson [1] proposes a prototype of a travel decision system for dealing with item recommendation to a group of two or more users. Zhu et al. [2] learn user-independent patterns and provide relevant Web pages to new users. Tezuka et al. [3] integrate Web search with a geographic information system, including discovering experiences from Web blogs, extracting landmarks from Web pages, and providing a new mode of presentation for the Web search integrated with GIS. Takasuka et al. [4] recommend Web pages based on URLs without any extra help from users. Oku et al. [5] present a context-aware ranking method for information recommendation using SVM. Compared to these researches, our work extracts tourist information from Web pages and recommends them to users for their route search.

Pedestrian or car navigation systems can also be categorized as information recommendation in a wide sense. Maruyama et al. [6] propose a personal navigation system called P-Tour for tourism. This system allows users to specify multiple destinations and time restrictions on arrival and staying time of each destination, and gives the nearly best schedule using a GA algorithm. The system given by Kawabata et al. [7] satisfies users' special requirements, such as providing a route without mud, a route without bumps or a route with well maintained security, rather than the shortest path. Another navigation system proposed by Akasaka and Onisawa [8] teaches pedestrians an appropriate route by using Sketch-map and fuzzy theory. Elias et al. [9] present an approach to identify landmarks and provide a landmark-based navigation system. Compared to these researches, our work focuses on the new aspect, the visibility of scenic sights for the route search. Hosokawa et al. [10] also consider landmark visibility, but their goal is to identify a user's current location, different from our route recommendation.

Several companies now provide some geographic information services. Yahoo! Local Maps [11] and Google Maps [12] show search results on a map interface. Furthermore, Google Earth [13], Microsoft Virtual Earth [14], Location View [15] allow users to explore richer geographical contents, such as satellite imagery, maps, terrain, 3D buildings, and even street level photographs. These commercial services maintain our motivation on the research of route search considering visibility.

3. System Overview

Figure 1 gives an overview of our proposed system. First, a user provides a region name to visit. Then, our system retrieves tourist spot and scenic sight information from the Web using a conventional search engine, and detects appropriate spots from the retrieved Web pages related to the region. Next, using the Web based interface of our system, the user can select several tourist spots and a scenic sight from the recommended information. The system receives the user's selection and recommends routes based on the selected spots and scenic sight by checking the visibility of the scenic sight for each route.

Our system recommends the route satisfying the user's two main preferences: visiting good tourist spots and viewing good scenic sights during a driving. The uniqueness of the proposed system is the recommendation of spots and scenic sights based on Web retrieval and analysis, and the recommendation of routes considering the visibility of scenic sights.

4. Spots and scenic sights recommendation

For recommendation, tourist spots and scenic sights near the location entered by the user are retrieved by searching the Web. A standard search engine is queried using the entered location and supplementary words. The examples of supplementary words are those which often appear in tourist Web pages, such as “sightseeing”, “tourist spot”, “landscape”, and so on. We make the further morpheme analysis on the search result pages for discovering tourist spots and scenic sights. The proper nouns including “general”, “region”, “organization”, are extracted. We sort these nouns by their term frequency (tf) values in the descending order and take the top ones as recommendation candidates. Our experimental results described later show this method is feasible though it is relatively simple.

After spots and scenic sights are extracted automatically, highly ranked ones are exhibited to the user. The user picks up the spots which he wants to visit and the scenic sights which he wants to view along the route. In our current system, spots and scenic sights are separately selected by the user. Certainly, automatically distinguishing scenic sights from general spots is greatly helpful to users, and developing such system is our future research.

After receiving the selected spots and sights, our system computes and recommends the best scenic route.

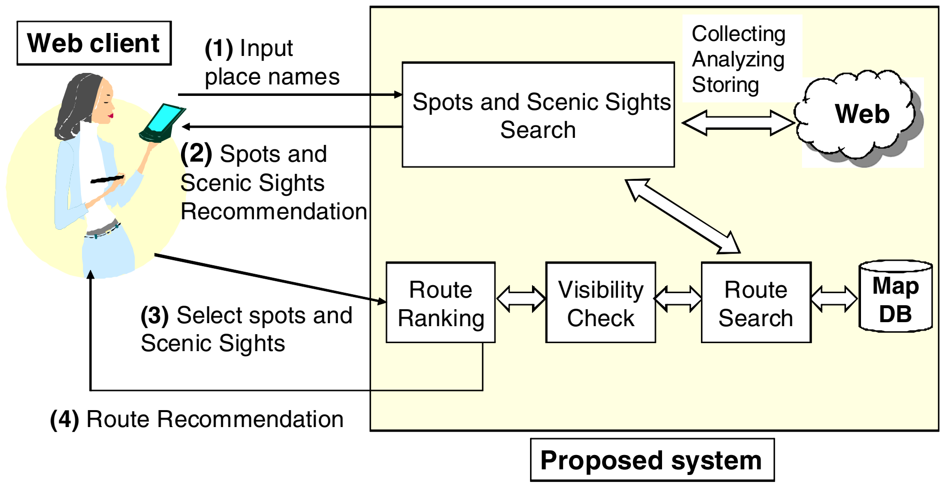

Figure 1. System overview

5. Route recommendation

5.1. Generation of route candidates

Route candidates for calculating visibility are generated by connecting several tourist spots provided by the method described in the previous section. In our current system, we generate route candidates via only one tourist spot; this means we connect a start spot, a tourist spot to pass through, a goal spot, to make a route candidate. Multiple route candidates are generated corresponding to different tourist spots to pass through. We use a GIS system called STIMS (Spatio-Temporal Information Management System) [16] to retrieve the shortest path passing through these three spots. The input of this system is the latitudes and longitudes of selected spots. STIMS first obtains the points on the road nearest to the three spots, and then finds the shortest path taking into account the type and width of the roads. As a result, the system outputs a route graph which consists of nodes set on the road and links connecting these nodes.

Generally, the nodes of the route graph are usually created at the forks on the road. Therefore, the distance between the nodes tends to be long for straight roads. To make a "regular" route with constant node interval, we also perform a normalization process to generate extra nodes between forks (Figure 2).

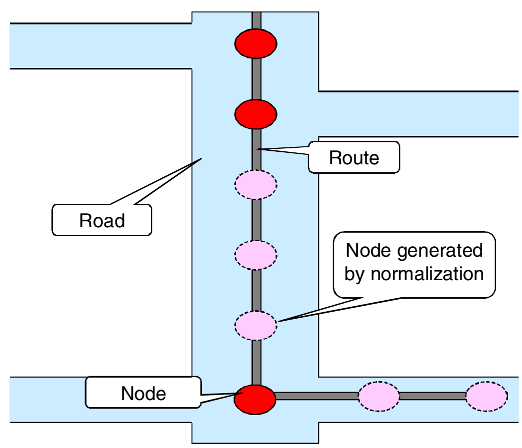

Figure 2. Route normalization

5.2. Visibility check of scenic sights

Z-Buffer (Figure 3) is one usual solution of the visibility problem, which decides whether a rendered scene is visible. When an object is rendered, the depth of a generated pixel is stored in a buffer called z-buffer. When another object is rendered in the same pixel, two depths (d_1 and d_2) are compared and the one closer to the viewpoint is chosen to replace the z-buffer. As a result, z-buffer restores the closest object, which means a close object is visible and hides other farther ones.

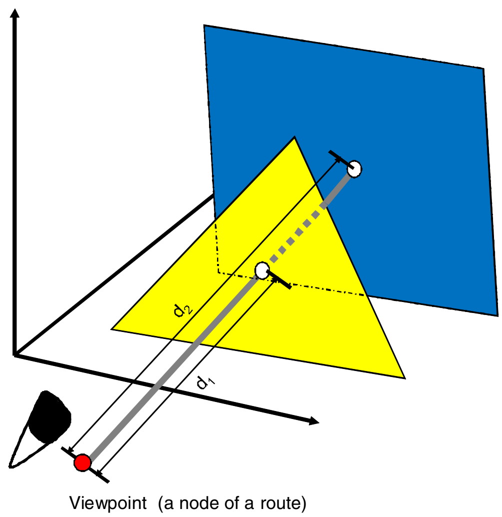

Figure 3. Z-Buffer

We construct a virtual 3D space and use the idea of Z-Buffer to decide the visibility of the scenic sight from a route. We obtain the three-dimensional data using a Digital Elevation Map (DEM), which is currently published by governments in many countries. The Japanese version provides altitude data with a grid interval of 50 m for the whole country. A 3D model in the computer can be constructed by converting the altitudes of the area surrounding the route to 3D polygons. Using this 3D model, the visibility can be calculated by rendering the target object (scenic sight) and checking whether it can be seen from each node on the route. In our current research, the visibility value for each node is defined as a binary level; "1" means the target object can be seen and "0" means it is invisible. The visibility value will be extended in our future work by considering more elements, such as attaching a numeric value proportional to the distance between the node and the scenic sight when it is visible.

Given a route candidate, the flow of the algorithm of visibility check is shown in Figure 4. First, the DEM data is read and the 3D space is constructed in the computer using the OpenCV [17] and OpenGL[18] libraries based on the locations of the route and scenic sight. Next, the visibility check is begun by flying the eyes from the current viewpoint (a node of the route) towards the scenic sight. The depth d_1 from the viewpoint to the object which can be seen is computed by the Z-Buffer method (step a), and then the distance d_2 from the viewpoint to the scenic sight is calculated (step b). After that, the visibility value is set to 0 or 1 by comparing d_1 and d_2 (step c); the visibility value becomes 1 if $d_1 = d_2$, whereas 0. The visibility data is stored into a file for later ranking of routes (step d). After moving the viewpoint to the next node and obtaining its altitude, steps from (a) to (d) are repeated until no nodes exist on the route candidate. The image of the visibility check from the whole route is shown in Figure 5.

The computational cost of the above process is high because the 3D model must be redrawn from all the nodes of the route. Therefore, we also propose a method to efficiently check the visibility. The 3D model is rendered only once from the scenic sight surrounding 360 degree (Figure 6). By this way, there is no need to redraw the 3D model, and thus, computational cost is significantly reduced, especially when a route is long.

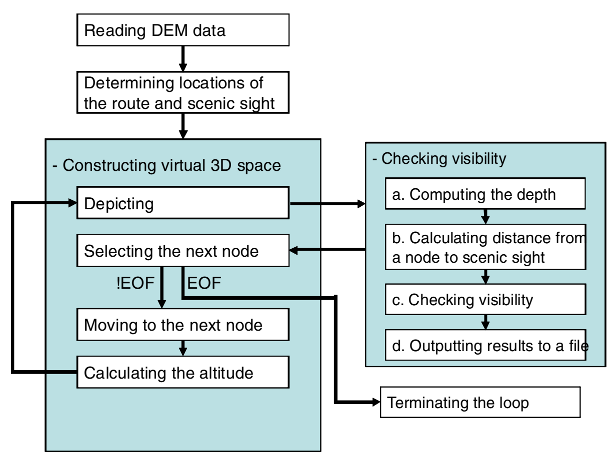

Figure 4. Flow of visibility check

5.3. Ranking of route candidates

Route candidates are ranked based on the average of the visibility values of all nodes. The calculation formula of the visibility rate s for a route candidate is as follows:

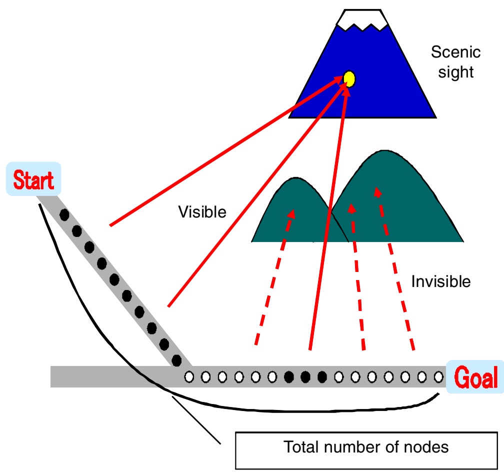

Figure 5. Visibility check from nodes

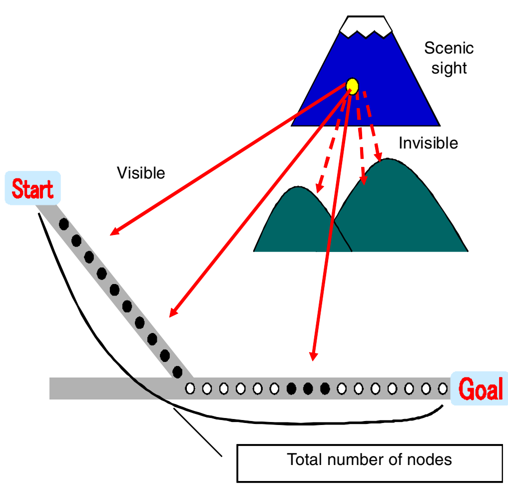

Figure 6. Visibility check from scenic sights

$$s = \frac{1}{n}\sum_{i=1}^{n} v_i \quad (1)$$

where v_i is the visibility value of the scenic sight from a node i on the route, and n is the total number of nodes on the route.

So far we have considered a scenic sight as a single point on the map. However, in the case that a scenic sight has a large region (e.g., a mountain), we sample multiple points from the region and calculate s for each sampled point. The total visibility rate S for a route candidate is calculated by taking the logical summation of m points of the scenic sight as follows:

$$S = \frac{1}{n}\sum_{i=1}^{n}\{\bigvee_{j=1}^{m} v_{ij}\} \quad (2)$$

That is to say, the visibility value for one node on the route is set to 1, if one or more sample points of the scenic sight can be seen from it.

6. Experiments

We used “Numeric Map 25000” for the generation of route candidates (Section 5.1), and “Numeric Map 50m Mesh” for the construction of 3D space (Section 5.2), both published by Geographical Survey Institute in Japan.

The search for tourist spots and scenic sights from the Web was programmed in Perl using Yahoo! Japan Web service [19]. The calculation of visibility rates was programmed in C++ using OpenCV [17] and OpenGL [18].

6.1. Extraction of spots and scenic sights

We carried out experiments to extract tourist spots and scenic sights in Japan. Prior to the experiments, we had to decide the number of results to use from the search engine. To decide the number of results, we calculated the accuracy and time of search by changing the number between 20, 50 and 100. The average searching time was found to be 41s, 70s and 139s. The accuracy corresponding to 50 and 100 results was very similar, and both better than that of 20 results. Therefore, we decided to use 50 results in our following experiments.

The accuracy was calculated as the ratio of appropriate spots to all the 20 recommendations (the top 20 spots with the highest tf values). The appropriateness was subjectively judged by 3 individuals. For example, when we inputted the place name “Mt. Fuji” as the search keyword, the recommendation results were as follows: 1st Lake Kawaguchi (tf value = 0.087), 2nd Shiroito waterfall (0.063), 3rd Country club (0.051); the 1st and 2nd were judged as appropriate ones by the individuals, however, the 3rd was regarded as inappropriate.

The average accuracy for a large area such as a prefecture was 63%, whereas that for a small geographical region such as municipalities was 86%. This was mainly because search results for the former case were collected from some portal Web sites which included many sightseeing information pages across all the country.

6.2. Calculation of visibility of scenic sights and ranking of route candidates

We conducted an experiment to show the effectiveness of the calculation of visibility of scenic sights and the ranking of route candidates. We selected "Mt. Buko in Chichibu-gun of Saitama prefecture, Japan" as a scenic sight, calculated the visibility, and ranked some route candidates.

Table 1. Comparison of visibility rates

sample point m	s of Route A	s of Route B
1	37.2	79.6
2	9.4	13.9
3	0.0	24.9
4	29.1	59.6
5	47.4	44.1
6	3.0	4.9
7	4.3	22.0
8	12.8	24.9
9	5.1	0.0
10	0.0	10.6
total visibility rate S (%)	68.8	96.7

Table 1 shows the comparison results of visibility rates for two of route candidates. The routes were regularized with the interval of 50 m, and the numbers of nodes on the two routes were 234 and 245 respectively. Since a mountain had a large area, we sampled $m = 10$ points for visibility rate calculation. Each row in Table 1 shows the visibility rate of each sample point of the scenic sight. As we can see, the visibility rates of different route candidates were different and they changed greatly corresponding to different sample points. The total visibility rate for Route B was higher than Route A. Although Route A and Route B were actually almost parallel, the difference of visibility rates was 28%. This was because Route A passed over the foot of another mountain (not Mt. Buko which the tourist wanted to view) and the view of the scenic sight (Mt. Buko) was obstructed. Therefore, Route B with the higher visibility rate is recommended rather than Route A, although Route

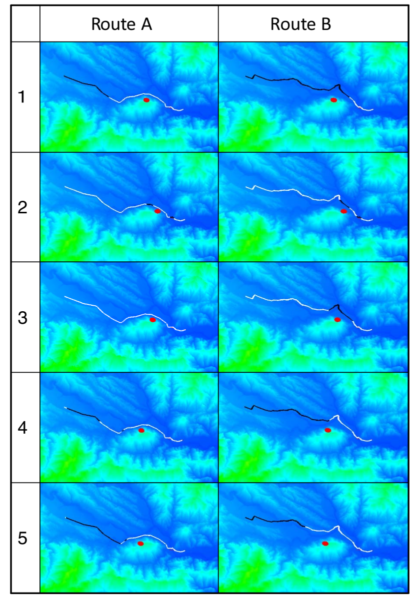

Figure 7. The images of visibility rates for sample points (Black lines are visible and white are not)

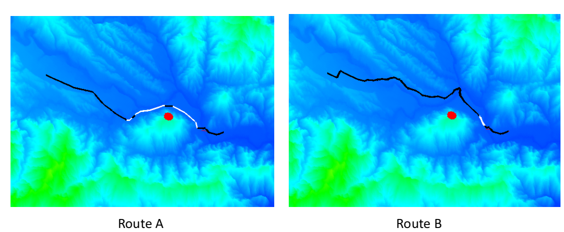

Figure 8. The images of total visibility rates (Black lines are visible and white are not)

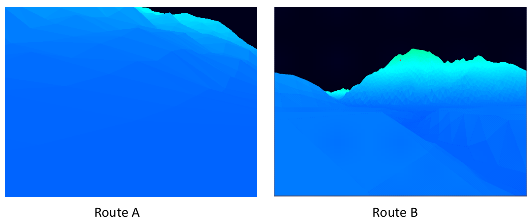

Figure 9. A sample view from a virtual camera towards the scenic sight

B is a little devious than Route A. The visibility images for five of sample points are shown in Figure 7, where the black parts of lines represent the parts of the routes from which the scenic sight can be seen, and the white parts represent invisible. The images of total visibility rates from two routes are depicted in Figure 8. Figure 9 shows a sample view from a virtual camera towards the scenic sight. The left image shows the scenic sight can not be seen from route A due to the obstacle, and the right one shows it is possible to view the scenic sight at the front.

7. Prototype

We have implemented a prototype of the proposed system. First, a user can input a place to visit by using a Web browser based interface. Then, the spots and scenic sights recommended by our system are shown in a ranking order. From the recommended keywords, the user can select four types of locations: a start spot, several spots to visit, a goal spot and a scenic sight. After receiving the selection from the user, the recommended routes are ranked based on the visibility rates and shown to the user. By clicking a route link, the corresponding route is displayed on the map and the virtual view of the scenic sight is shown as a movie.

Figure 10 shows the Web interface of our proposed system. The upper right part provides recommended spots which can be selected by the user, and the bottom right part shows recommended routes with their visibility rates. The upper left map gives a route search result on the Google Maps, and the bottom left frame presents a movie of a virtual 3D view.

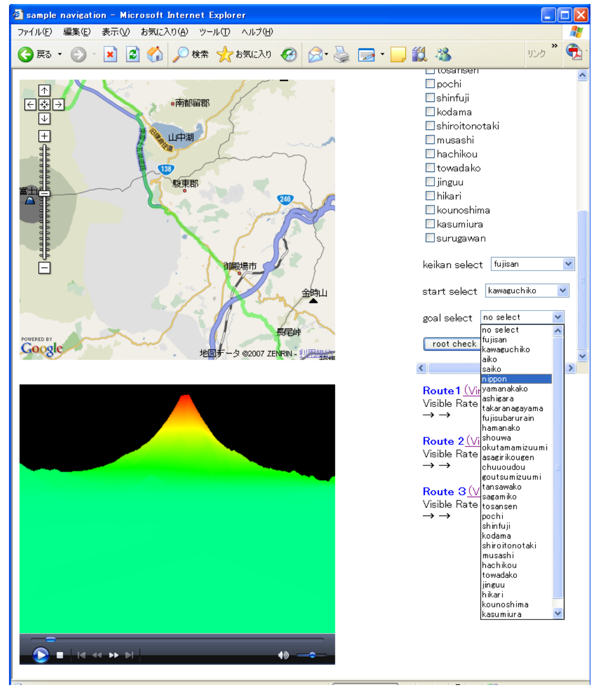

Figure 10. Web browser interface

8. Conclusions and future work

In this paper we proposed a system which can recommend popular tourist spots and scenic sights based on Web information analysis, and calculate routes with the best view of a scenic sight from a car. As shown in the experimental results, the tourist spot information was extracted with high accuracy. Moreover, by using three-dimensional data and geographical information from a digital map, the visibility rates of routes were calculated effectively. In our method, by considering the scenic sight as an area instead of a point, the accuracy of visibility rates was greatly enhanced. We also implemented a prototype of a navigation system which can successfully recommend tourist routes with good scenery.

There are still a number of interesting work which need to be carried out. Using a numeric value for the visibility of a scenic sight for a node is expected to improve the results. The generation of route candidates which allows multiple passing spots is also an important extension. We plan to infuse more factors in addition to temporal information, such as weather, seasons, and traveling time (daytime or nighttime) in the future system.

9. Acknowledgment

This work was supported in part by SCOPE (Ministry of Internal Affairs and Communications), Japan, and by MEXT Grant-in-Aid for Scientific Research in Priority Areas, Cyber Infrastructure for the Information-explosion Era (#19024073).

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