Adaptive Landmark-Based Pedestrian Navigation System with Hand-Held and Wearable Devices

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Abstract. Mobile navigations help people to find route faster and easier. However, current pedestrian navigations provide the same route information as the instructions of car navigation with little consideration for pedestrians. Mobile pedestrian navigations should consider pedestrian walkways and device capabilities. In this paper, we propose a landmark-based navigation system for pedestrians based on the user's locational context and the capabilities of hand-held and wearable devices. The system generates turn-by-turn routes and mashups landmarks with social media contents. The system provides context clues on wearable devices, and the overall context on hand-held devices to assist pedestrians who are unfamiliar with an area.

Keywords: Pedestrian navigation · Landmark-based · Hand-held and wearable devices

1 Introduction

With the sharp increase of wearable devices connected to smartphones and tablets, pedestrian navigation systems using these devices are also on the increase. However, current pedestrian navigation instructions are similar to the instructions of car navigation except that they use the pedestrian walkways. The car navigation methods are not suitable for the pedestrian navigation, as pedestrians have more freedom of movement than drivers, and they are much slower [1]. The pedestrian navigation systems should provide information considering these new device capabilities and usage patterns of pedestrians because of the different form factors and modalities by wearable devices.

The pedestrians need detailed information about salient objects, such as landmarks, rather than road networks to reach a destination. May et al. [2] concluded that landmarks are the main navigation cues used for providing directions to the pedestrians as opposed to road junctions and signs in car navigations. The social media contents like panoramas and photos can be collected to enrich description of landmarks and give locational context cues for the users. Hile et al. [3] proposed a system that automatically generates landmark-based pedestrian navigation instructions from existing

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collections of geo-tagged photos. Shuhui et al. [4] presented a representative image generation system using user generated geo-tagged photos based on popular shooting locations.

In this paper, we propose an adaptive landmark-based pedestrian navigation system that generates landmark-based navigation instructions using a point of interest (POI) database and augmented multimedia from social media to describe the route point. In addition, we divide navigation instructions into two steps for providing suitable navigation instructions based on the user's device capabilities and locational context: partitioning route path into landmark-based path guide (Step 1) and direction guide to the next route point (Step 2).

2 Our Method

In Fig. 1 the pedestrian route planner generates landmark-based navigation instructions for the user, and the adaptive pedestrian route handler manages the hand-held and wearable navigation views. The map server provides map tiles to render maps on the device views.

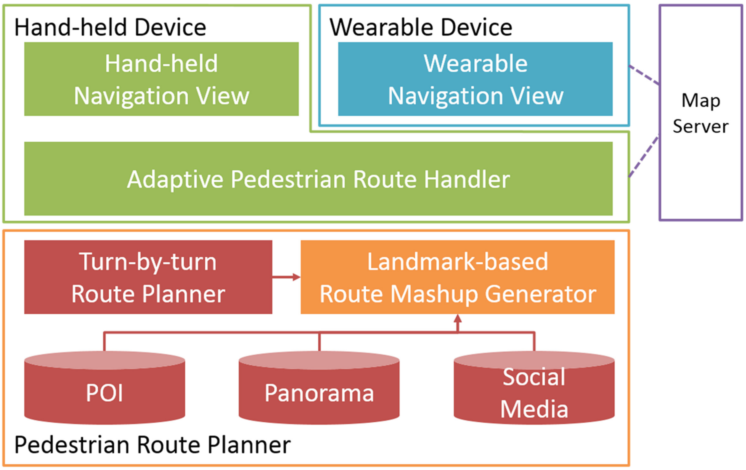

Fig. 1. Overview of proposed architecture

2.1 Landmark-Based Pedestrian Navigation Generation

When a user selects a destination POI, the system obtains the current position of the user and passes the locations to the pedestrian route planner, as shown in Fig. 1. To provide landmark-based pedestrian navigation, the landmark-selection process depicted in Fig. 2a is required for each route point. The turn-by-turn route planner passes route points to the landmark-based route mashup generator.

The route generator retrieves nearby POIs from OpenPOIs [5] as the POI database and chooses candidate POIs over the road of a route point based on the walking direction and the field of view of the user, as shown in Fig. 2a. The route generator scores and ranks the candidate POIs to choose a landmark of the route point based on the proximity of the landmark to the road and its height compared to surrounding buildings with a higher score being given to a POI that is closer to the road and taller against surrounding buildings. The orange POI in Fig. 2 is the landmark, and the green POIs are not selected as landmarks because of the height of the building is lower than the orange POI. In addition, the route generator chooses a panoramic photo based on the location of the route point from Google Street View [6] and photos taken in the blue locations in Fig. 2a and tagged by the name of the landmark POI from Panoramio [7] (a location-based social photo sharing site). According to the locational context of the user, the hand-held device renders the overall context on the map. The route generator mashups turn-by-turn route plan, the selected landmark, a photo about the landmark, and panoramic view using location information of these resources to provide landmark-based route instructions based on user's location cues and device capabilities.

2.2 Adaptive Navigation Guide for Wearable Devices

The movement from the current position to the destination POI involves going to the next target route point from the current route point in the route path, as shown in Fig. 2b. In this paper, we divide this process into two steps: landmark-based path guide (Step 1) and direction guide to the next route point (Step 2). The adaptive pedestrian route handler in a hand-held device, shown in Fig. 1 manages the navigation views of hand-held and wearable devices based on locational context. The hand-held device tracks current position of the user and compares the location to the target route point to change adaptively modes and views of the wearable device between the first and second steps based on locational context. When the user starts the movement to the

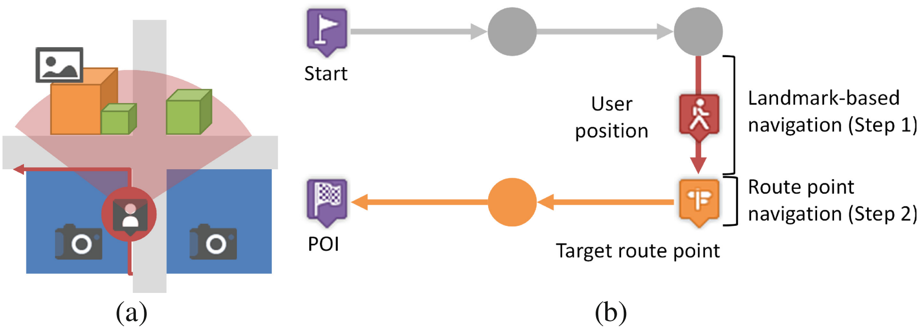

Fig. 2. Process of landmark-based pedestrian navigation: (a) landmark and social media selection-based route path and (b) partitioning route path into landmark-based path guide (Step 1) and direction guide to next route point (Step 2). (Color figure online)

target route point, the adaptive pedestrian route handler shows the first step in Fig. 2b on the wearable device. When the user arrived within a ten-meter radius, the wearable device's mode and view are changed to the second step. After changing to direction, the mode and view are changed into first step.

The goal of the first step is to move from the user's current position to the target route point. Required routing information includes the distance and direction of the target route point and a photo of the landmark at the location of the target route point. The second step begins when the user nears the target route point, and information on the direction of the next route point is provided to change the walking direction of the user. The wearable device (e.g., Google Glass) depicts the distance and direction of the target route point and a photo of the landmark in the first step. In the second step, the wearable device renders the current route path, position, and direction of the user on the map and a panoramic view, the angle of which is animated based on the user's progress toward the next route point.

3 Experimental Results

We implemented a prototype pedestrian navigation system using a Google Glass and a Google Nexus smartphone to verify the usefulness of our approach. Figure 2 shows the screenshot of the hand-held and wearable devices providing navigation information. The overall context of the route information is shown in Fig. 3a. The routing path is

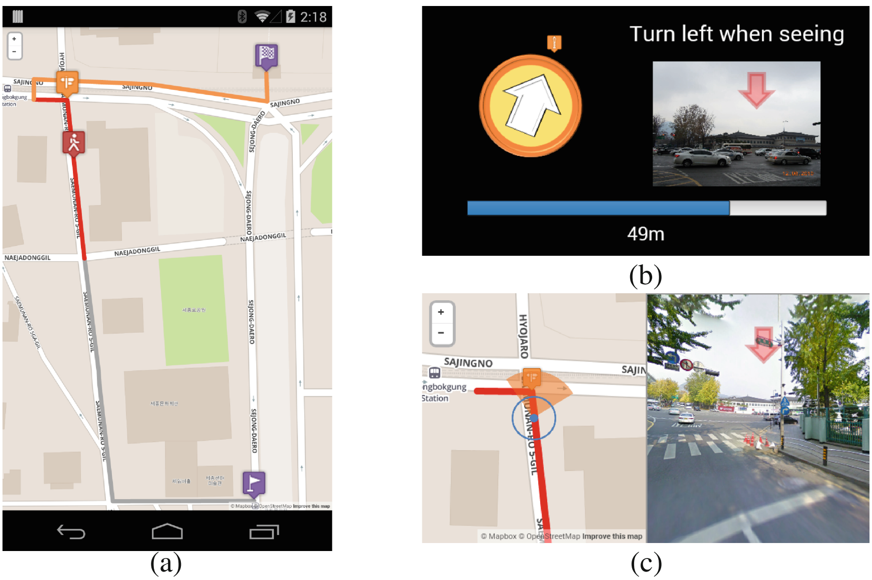

Fig. 3. Implementation of pedestrian navigation system: (a) Overall context on hand-held device (Google Nexus smartphone), (b) landmark-based navigation for finding route point on wearable device (Google Glass), and (c) route point navigation for turning to next route point on wearable device. (Color figure online)

from a subway station to the Gyeongbokgung Palace in Seoul, Korea. A navigation path from the start point of the user to the destination POI is presented on the map. A gray line represents the path the user has completed, a red line represents the current path, and an orange line represents the future route path. A red marker represents the current position of the user and an orange marker represents the current target route point.

Figure 3b and 3c present navigation information on the wearable device depending on the user's context. As the user goes to the target route point, the wearable device shows landmark-based navigation information as shown in Fig. 3b (i.e., the first step in Fig. 2b). In this step, the user's direction, remaining distance, and a photo of the target route point are shown. When the user arrives at the target route point, the device then provides the direction of the next route point, the user's direction on the map, and a panoramic view of the current route point, as shown in Fig. 3c. The angle of the panoramic view is animated from the user's current progress direction toward next route point (i.e., the second step of Fig. 2b).

4 Conclusion

In this paper, we proposed an adaptive landmark-based pedestrian navigation system. Our approach separates route instructions into two steps: one for landmark selection and the other for landmark-based pedestrian instructions based on the combined capabilities of hand-held and wearable devices and the user's locational context.

Using the proposed system, a pedestrian receives route information with the overall and locational context with hand-held device. The pedestrian is aware of an overview of the whole navigation paths for overall context. On the other hand, the instructions on wearable device help people to find target route points with specified information such as landmarks and user's direction.

In the future, we will conduct a user study to evaluate our proposed system, and then we will improve our approach according to the study results.

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