Decision-Point Panorama-Based Indoor Navigation

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Abstract. We present a novel user interface concept for indoor navigation which uses directional arrows and panorama images at decision points. The interface supports the mental model of landmark-based navigation, can be used on- and offline and is highly tolerant to localization inaccuracy.

1 Significance and Simulation Results

Reliable indoor navigation is an enabler for many novel context-based services (CBS), and currently of high interest in research. While WLAN fingerprinting or (optical or radio-frequency-based) marker-based technologies rely on the infrastructure, *vision-based localization* [1] using content-based image retrieval (CBIR) is a promising alternative for localization that works in both indoor and outdoor environments, given that reference images are available. However, research currently focuses on technologies and few work is dedicated to the human-computer interaction perspective.

This paper is grounded upon an evaluation of interfaces using augmented reality (AR) views and panorama images for indoor navigation [2]. In a large-scale study, we compared the perceived guidance quality of those approaches in light of localization accuracy (one of the most significant challenges in indoor navigation) [3]. We simulated different types of inaccuracy (localization errors, orientation errors, or both combined) and showed that AR instructions are prone to be misoriented or misaligned to the real-world scene in case of wrong location or orientation estimates. Direction arrows in panorama photos, by contrast, allowed users to orient themselves also in case of significant localization errors. Overall, users perceived panoramas to be more accurate in practice, compared to AR. However, we also learned that updating panoramas every few meters is not optimal, as such rapid changes of the interface can be irritating for users. We therefore present a novel concept using panoramas at decision points.

2 Decision-Point-Based Navigation (DPBN) Using Panoramas

We describe the route as a sequence of route segments. Each segment has a length and an angle indicating the turn to the next route segment. The nodes connecting route segments are called *decision points*, as the user can decide which path to follow (e.g., follow a corridor straight ahead, turn left or right, etc.). For each decision point, the route description contains a 360 degree panorama image shot at that position and a superimposed directional arrow (see Fig. 1, left, for some examples on a route). Images were obtained with a panorama camera mounted at a mapping trolley. Since the building has been mapped for vision-based localization anyway, obtaining those images is no additional effort. Our concept provides several advantages.

Offline Usage. The user can flick through a list of panoramas representing the route summary step by step both online and offline (i.e., without active localization), e.g., also when localization fails, no WLAN is available or to memorize the route in advance.

Mental Model Familiarity. The interface matches the familiar mental model of self-orientation and route instruction memorization (e.g. "turn right in the hall in front of the library, then walk straight ahead until the elevator and turn left straight before..."). In particular, the inclusion of landmarks is supported, as the user sees images of all important decision points.

Error Tolerance. During localization, the panorama of the subsequent decision point is automatically loaded (see Fig. 1, right). Be d the distance between two subsequent decision points (typically ranging between few meters and several dozens of meters in large buildings), the system works correctly when the localization uncertainty is below $d/2$, which makes it highly error-tolerant. The user can acknowledge that he passed a decision point by tapping on the screen which additionally adds ground truth to the system.

Our novel approach is suited to increase perceived reliability at high error tolerance and will be formally evaluated in a user study in future work.

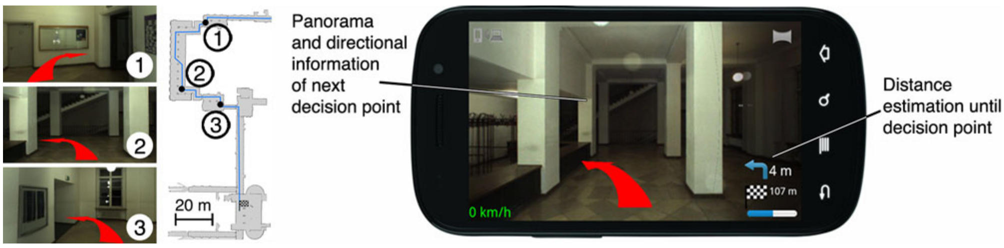

Fig. 1. A route description is represented by a sequence of panoramas (obtained from reference image data) at decision points and turn instructions (left). Even if vision-based localization is inaccurate, the user interface (right) can display the next decision point's panorama, which allows reliable landmark-based self-orientation.

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