Interaction of Mobile Camera Devices with physical maps

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Abstract. Traditional paper-based maps are still superior to their digital counterparts used on mobile devices in several ways. They provide high-resolution, large-scale information with zero power consumption. On the other hand digital maps provide personalized and dynamic information on request, but suffer from small outer scales and low resolutions. In this work we try to combine the advantages of both by using mobile camera devices (such as smartphones ore PDA) as a map-referenced magic lens that displays geo-referenced information on top of the physical map. We will mainly focus on the interaction schemes that arise from using mobile camera devices with physical maps and briefly explain how the device tracking over existing physical maps can be realized.

1 Introduction

In many mid- to large-sized cities public maps are ubiquitous. They help to facilitate orientation and provide information to tourists but also to locals who just want to look up an unfamiliar place while on the go. These maps are usually designed to address the most common questions of average users and therefore contain only the most necessary information, such as street names and places of interest. More specific information, such as locations of ATM machines, pubs, shops and restaurants would visually clutter the map and are therefore not included. Digital requests can be answered by using mobile devices, such as PDA and smartphones with network connectivity by querying an adequate web service, which returns a dynamic digital map with the desired content. These maps suffer from a small outer scale (due to the small display size) and a rather small inner scale. It is often hard to identify locations and landmarks on these maps, rendering them rather useless. In this paper we combine the advantages of large scale paper-based but static maps with small dynamic maps on mobile devices. We apply a magic lens approach [7] that makes use of mobile camera devices. The main idea is that the camera image of the physical map is augmented with dynamic content, for example locations of ATM machines on the map. By moving a tracked camera device over the physical map (see figure 1) users can explore requested digital content available for the whole space of the map by just using their mobile PDA or smartphone as a see-through device. For this purpose the mobile camera device has to be tracked over the physical map (see section 3),

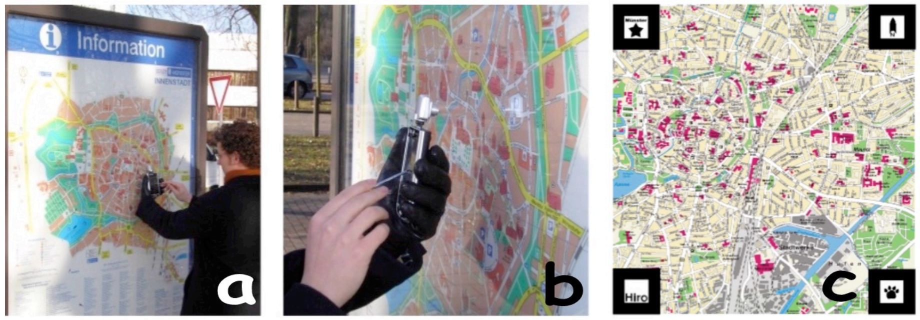

Fig. 1. Interaction of Mobile Camera Devices with physical maps

and appropriate map interaction concepts are needed (section 4). We will also provide some details on the implementation and start with a brief review of related work.

2 Related Work

Our work builds upon existing work on mobile augmented reality. To track the device over the map we apply the marker-based approach developed by Wagner and Schmalstieg [6] to the domain of physical maps. Our work is similar to that of Reilly et al. [2], where a physical map is equipped with RFID-tags, which allows a mobile device, equipped with an RFID-reader to identify certain spots and display corresponding information. However, in our work we follow a magic lens see-through approach and use a mobile camera device. We are inspired by the interaction concepts developed by Rohs and Roduner [4], but specifically look at the interaction requirements in the map domain.

3 Device Tracking and Marker Integration

To track the device in respect to the map, we are currently using *ARToolkitPlus* [1] markers. The marker based approach is very robust, but in our case its main disadvantage is that it obscures parts of valuable map space. We have tried to address this problem in several ways: semi transparent markers (up to 15% transparency), multiple but smaller markers (see figure 1c), and markers with map content such as a north arrow, a parking place symbol or even markers with commercial information. When seen through the display, markers can be covered by an appropriate digital patch of the map (the effect can be seen on the system screen-shots in figure 2).

A special marker should be used to identify the type, the outer boundary and the scale of the map.

Most physical maps are nowadays designed with the help of dedicated Geographic Information Systems, that can also be used to easily geo-reference the markers. For this purpose, the markers are inserted as additional map objects and stored along with the geodetic coordinates of the marker's center and the orientation of the marker's coordinate system. This approach makes it very easy to design maps with integrated markers and a correct geographical reference. Further achievements in tracking could be obtained by combing a marker-based approach with optical flow analysis [3]. Given the fact that city maps are usually highly structured, we are currently also exploring the possibilities to apply structural image analysis to the tracking problem.

4 Interaction Concepts

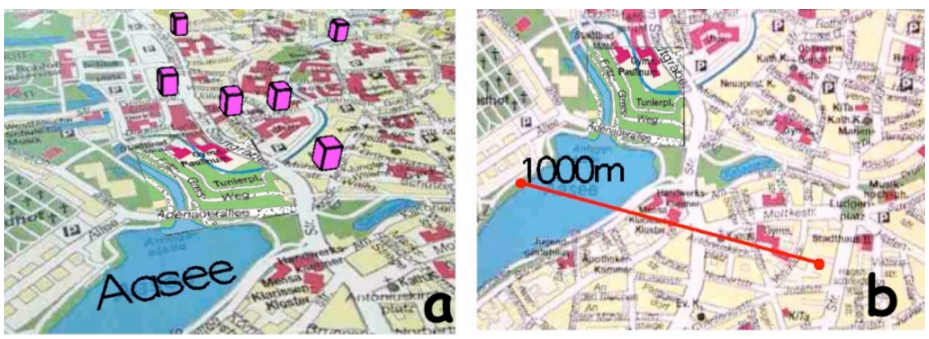

Fig. 2. A Screenshot of the mobile devices. The Marker is masked by a map from a Web Mapping Service: a) ATMs in Münster b) Measuring Distance

The basic interaction pattern is that of *sweeping* the camera device over the map (as described in [4] and seen in figure 1). Moving the camera towards or away from the map will lead to a smaller or greater portion of the map being visible on the display. In combination with keystrokes dedicated geo-services can be triggered, e.g. a routing service that calculates a route from the actual position to the designated location[1]. For the selected area specific geofeatures can be requested from a Web Feature Service[2]. The result of an request to display available ATM-machines is shown in figure 2a.

Another obvious interaction concept is that of *map annotations*. Allowing users to annotate physical maps with arbitrary kind of information (e.g. locations

[1] In case of city maps the location of the user is known and thus only the identification of destination is needed.

[2] A Web Feature Service (WFS) is a highly interoperable and standardized protocol, that allows for requests for geographical features across the web.

of good pubs or interesting shops) has the great advantage that this information is geo-referenced without the need of any external location technology (such as GPS).

Calculating distances between two designated locations on the map by pointing is straightforward. As seen in figure 2b users just need to mark two designated points on the physical map.

5 Summary and State of Implementation

This paper has discussed an approach to access digital geo-referenced content through a mobile camera device (such as a PDA or a smart phone). By applying a magic-lens approach we have shown that high resolution and large scale physical maps can be augmented with dynamic and personalized content without requiring great changes in the infrastructure.

The current implementation runs on a PDA with a SD-camera. The content is retrieved over a wireless connection from a Geographic Information System. We are investigating the possibility to run the system on a MDA Pro (HTC Universal) from T-Mobile with a 1.3 mega pixel camera running under Windows Mobile 5.0.

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