Mobile augmented reality to identify mountains

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Abstract. The paper describes the implementation of a mobile augmented reality application for identifying mountains on the Apple iPhone. The presented prototype includes a novel approach for correcting inaccurate sensor data with manual user input and uses a web service to display only mountains which are actually visible from the user's point of view.

Keywords: mobile, augmented reality, geo-information systems.

1 Introduction

It does feel great to get a panoramic 360-degree view of the horizon encompassing snow-topped mountains splattered with the myriad hues of a setting sun. Experiencing such a great moment in nature it does not take long until one asks "what's the name of this peak over there?" or "in which direction from here is Mount Anonymized".

Frequently visited panoramic view points sometimes feature installed panorama signs that show you the directions for different mountains in sight from that very position. However, most of the time you can only ask a local guide, or aligning a map to mountains in sight, which is not really a trivial task.

Today many mobile phones can locate their position using either GPS or wireless positioning. In addition digital compasses and accelerometers provide the horizontal and vertical orientation of the phone. The combination of these features allows to superimpose information over objects displayed on the screen captured by the phone's camera.

Several systems for mobile augmented reality exist on various platforms [1,2,3,4]. Just recently, first applications for identifying mountains have appeared on Apple's iPhone [5,6]. This paper describes our implementation of a light-weight augmented reality application for the iPhone, which provides users with information about mountains in sight. Mountains seen through the phone's camera get labeled with their name, height and the distance from the user. Then, further information for specific mountains can be requested from the web.

The application uses location, digital compass and accelerometer of the mobile phone to display the overlay over the camera image. In addition, it can access a geo-information service to display only the visible peaks of the observer's viewpoint. In contrast to other approaches [7] we do not use image recognition, optical markers or any other computational expensive techniques. In the following we describe our implementation and first experiences with it.

2 Design Challenges

Accuracy of digital compass. First tests showed that accuracy of the phone's built-in digital compass is limited and prone to interference, e.g. when using it near metal surfaces or electric currents.

Accuracy of location information. Location information varies based on the line-of-sight to available GPS satellites. Additionally, the height information is even less accurate, typically by a factor of two to three compared to the horizontal location.

Field of view. Based on location and heading the actual view captured from the phone's camera has to be calculated. Then the visible horizontal and vertical viewing angle can be mapped to the actual screen pixels of the mobile phone in order to superimpose the information over the image accordingly.

Selection of mountains to display. Only those visible mountains not occluded by higher mountains in the foreground should be selected for display. Furthermore, in order not to overload the screen and the CPU, the selection of labeled mountains has to be limited in a meaningful way. Tests showed that 60 peaks are reasonable.

Retrieve information. Mobile Internet connectivity may be rather limited in remote mountain areas. Accordingly, ways of caching have to be found in order to have the application working also without connectivity.

Calculation of the information overlay. The 3D location information of the mountain has to be mapped to the actual view as displayed on the phone's screen. This has to be achieved in reasonable time to match the video image's refresh rate and allow for a smooth user experience.

3 Description of the Prototype

Our implementation of the augmented reality application uses the iPhone SDK 3.1. which provides an API for overlaying camera's video live-streams and access to the digital compass. The compass provides horizontal orientation of the phone, vertical orientation is derived from the accelerometer.

Combining these measured parameters with the actual field of view – which we calculated using the physical properties of the iPhone camera lens: 50.1° horizontally, 34.6° vertically – data can be mapped to the screen dimensions with 8.5 pixels per horizontal degree and 9.2 pixels per vertical degree.

Sometimes an icon's location on the screen and the mountain's location in the camera image may not be correctly overlaid due to inaccurate GPS/compass data. The demo makes this error information visible with a semi-transparent rectangle around the information icons. Depending on the error range the color of the area goes from red to orange to green (see Figure 1, left).

The user can also correct this error manually: tapping on the compass in the bottom left corner of the screen enters the calibration mode, dragging the overlay over the video stream adjusts the horizontal and vertical offset with simple finger movements. Thus, for a given location and environment the sensor error can be manually corrected. The correction values are shown in arrows around the compass.

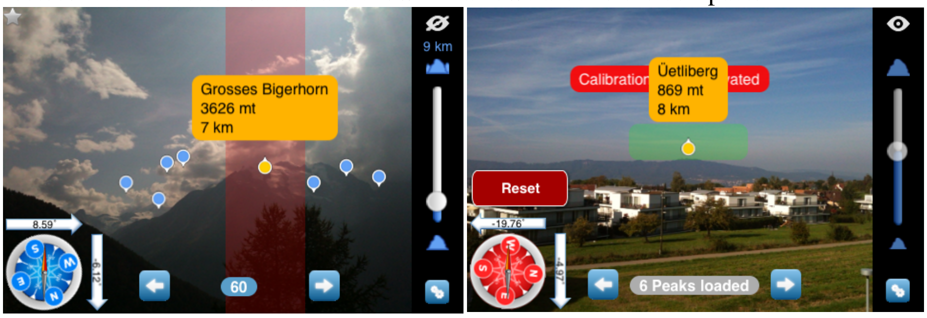

Figure 1: superimposition of peaks (left), calibration mode (right)

To find out, whether a peak is visible from a certain viewpoint, so-called view-sheds of 89 selected peaks are calculated: based on the terrain surface those locations from which a peak is visible are labeled (see Figure 2). Currently, a web-service provides access to view-sheds of 89 selected dominant peaks in Anonymized land. Queries are returned in less than half a second. The number of peaks with visibility information will be increased in the future.

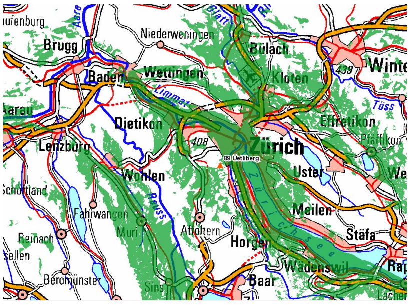

Figure 2: 1 out of 89 view-sheds: from the green areas [anonymized] is visible.

For all other peaks without calculated view-sheds – the mode can be switched by the eye-icon in the upper right corner - a reverse geocoding service derives the current country the user is in in. Then mountains of the country can be downloaded from geonames.org and stored on the phone locally. Based on the phone's current view, the mountains to display are selected for the calculated overlay. The displayed peaks are limited to a number of 60 in order to preserve a satisfying refresh rate and user experience. A slider selects the maximum distance from the current location to the mountain to display (see Figure 1, left, right edge). If the returned result exceeds the threshold of 60 mountains, the user is asked if the set should be limited by either the closest or highest peaks. The user's decision is saved and can later be changed in the application preferences. Furthermore, favorite peaks can be bookmarked preserving the user's preferences.

Each mountain within the field of view is displayed by a blue peak icon. The peak nearest to the center is pre-selected highlighted in yellow. A label displays name, height and distance of the selected peak (see Figure 1, left). The user can navigate through the selected mountain using the left/right arrows at the bottom of the screen. When the user taps on the label of mountain a browser window opens wikipedia for additional information using the mountain name as a query string. For Anonymized land the prototype queries a user-generated tour description repository.

More details about the implementation can be found on our development website[1].

4 Discussion and Conclusion

We showed how information available today in geo-information systems can be made available to non-professional users providing value in a meaningful and intuitive way. The presented prototype works with mobile phone sensor data only without requiring more advanced AR techniques such as image processing and object recognition. It also allows users to correct inaccurate sensor data with manual input.

First informal evaluations with mountaineers testing the applications were positive. We see this as an indication to continue this work, conduct additional tests and user studies, and extend the application with more features in the future.

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