Photomap: Snap, Grab and Walk away with a 'YOU ARE HERE' Map

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ABSTRACT

One compelling scenario for the use of GPS enabled phones is support for navigation, e.g. enabling a user to glance down at the screen of her mobile phone in order to be reassured that she is indeed located where she thinks she is. While service based approaches to support such navigation tasks are becoming increasingly available – whereby a user downloads (for a fee) a relevant map of her current area onto her GPS enabled phone, the approach is often far from ideal. Typically, the user is unsure as to the cost of downloading the map (especially when she is in a foreign country) and such maps are highly generalised and may not match the user's current activity and needs. For example, rather than requiring a standard map on a mobile device of the area, the user may simply require a map of a university campus with all departments or a map showing footpaths around the area in which she is currently trekking. Indeed, one will often see such specialised maps on public signs situated where they may be required (in a just–in–time sense) and it is interesting to consider how one might enable users to walk up to such situated signs and use their mobile phone to 'take away' the map presented in order to use it to assist their ongoing navigation activity. In this paper, we are interested in a subset of this problem space in which the user 'grabs' a map shown on a public display by taking a photograph of it and using it as a digital map on her mobile phone. We present two different scenarios for our new application called *PhotoMaps*: In the first one we are having full control on the map design process (e.g. we are able to place markers etc., in the second scenario we use the map as it is and appropriate it for further navigation use.

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Categories and Subject Descriptors

H.5.1 [**Multimedia Information Systems**]: Artificial, augmented, and virtual realities, hypertext navigation and maps

Keywords

Maps, mobile camera devices, navigation, location, GPS, interaction, public signage, situated displays

1. INTRODUCTION

In many mid- to large-sized cities public maps are ubiquitous. But even outdoors you find a great number of maps in parks or near hiking trails. They help to facilitate orientation and provide specialist information to tourists but also to locals who just want to look up an unfamiliar place while on the go. These maps offer many advantages compared to mobile maps from services like Google Maps Mobile or Nokia Maps. They often show local landmarks and sights that are not shown on the standard digital map on the mobile. Often these 'You are here' maps are adapted to a special use case, e.g. a zoo map or a hiking map of a certain area. Being designed for a special purpose these maps are often aesthetically well designed and their usage is therefore more pleasant.

In this paper we show concepts how one might enable users to walk up to such situated signs and use their mobile phone to 'take away' the map presented in order to use it to assist their on–going navigation activity. We are interested in a subset of this problem space in which the user 'grabs' a map shown on a public display by taking a photograph of it using her mobile phone. A special application on the mobile phone has to make sure that the image is correctly georeferenced and transformed to correct distortions that are due to the photographic process.

The phone would then perform image recognition in order to identify the 'You are here' indicator, so that the users can walk away with their 'You are here' PhotoMap and using their GPS enabled device to navigate through it. The original visual representation of the 'You are here' indicator could then be used to dynamically reflect the user's

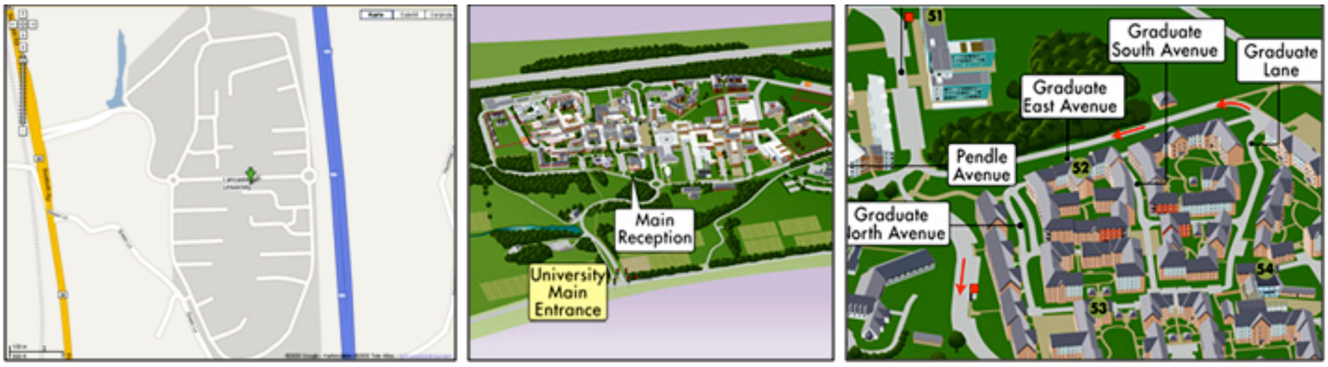

Figure 1: Comparison of a map by Google Maps and a locale map of the campus of Lancaster University, UK.

current position. The remainder of this paper is structured as follows. Section 2 describes two scenarios. Next, Section 3 summarises key technical challenges and limitations of both approaches are discussed in Section 3 while related work is presented in Section 4. Finally, Section 5 provides some concluding remarks.

2. SCENARIOS

The following two scenarios illustrate the concepts more fully. In the first scenario metadata for georeferencing the map is encoded in visual markers that are printed in the corners of the map. Optionally, a vectorised map is produced from the photo of the map. In the second scenario the grabbed map remains as a georeferenced raster image, but with the advantage that the 'You are here' map is not modified and this approach will work with every 'You are here' map in our surroundings.

2.1 SCENARIO 1

Consider the following scenario. Jane, a wheelchair user, is visiting Lancaster University for the first time and arrives in Alexandra Square in the centre of the campus. She is interested in exploring the campus but eventually wants to end up at InfoLab. In the Square she notices a simple 'You are here' type map displayed on one of the public notice boards and is pleased to see that the map has been printed in a design that is compatible with the 'You are here' application which she has installed on her GPS enabled phone. So she starts up the application and takes a picture of the map (which shows walkways and key places around campus and routes that are recommended for wheelchair access) using her phone's camera. The application performs some basic perspective correction and georeferencing. Optionally an image recognition step is performed in order to create a georeferenced vector based map in which vectors may contain attributes such as 'wheelchair compatible'. In more detail, this stage includes the detection and decoding of the visual markers, e.g. a visual code [9], displayed at the corners of the map. These codes are first used to carry out basic perspective correction. In addition to that the markers store the world file information to georeference the image. World files are used by geographic information systems (GIS) to coordinate raster map images upon completion. These files contain information that relates print size extent in map units, north direction, and the x,y-coordinates of the upper left corner in a specific format. Upon completion an algorithm, like implemented in the open source GIS Grass [4], can perform an raster to vector transformation in order to create a personalized vector map to supply the special needs of a wheelchair user. This process should ideally take not more than 2-3 seconds. The vector map is then displayed on the screen of Jane's mobile phone together with a 'You are here' icon. Jane can now move through campus and see the 'You are here' icon move appropriately (see Figure 2).

2.2 SCENARIO 2

Fredo is walking above Lake Molveno in Northern Italy. He approaches a map of the area for walkers (see Figure 4). Fredo takes a picture of the map with his GPS enabled phone and performs some additional actions (described in detail in Section 3) to do the georeferencing manually in an easy and appealing way. For that we utilize the current GPS positions where Fredo took the photo and the GPS trace in order to establish the map's scale and performs image recognition to identify the position of the 'You are here' dot shown on the map. This can be verified by the current lat/lon coordinated coming from the phone's GPS unit. In this case, the map remains as a raster image on Fredo's phone (see Figure 5), because it contains height information and additional useful information such as information on the vegetation. But of course in this case a map vectorization can be applied, too. Note that the 'You are here' dot shown in the physical map is in some sense redundant but would provide a very useful reassurance to Fredo as on observing the map on his mobile phone the dot should appear in the corresponding position (see Figure 5, left). As the map is raster based Fredo is able to zoom the map but at a certain level of zoom pixilation may result.

3. TECHNICAL CHALLENGES AND LIMITATIONS

In both of the two scenarios two major technical challenges have to be encountered: the *georeferencing* of the map and the *correction of the distortion* of the map due to the rather uncontrolled way the image has been taken. In the first scenario visual markers have been printed on the 'You are here' map to solve both problems. In the second scenario the 'You are here' map is taken as it is, which makes the solution more challenging. Optional technical challenges are in both scenarios the *image recognition of the* 'You are

Figure 2: Approaching the public sign/map of Lancaster Campus (left) and the map itself (right) as it might appear with visual codes. Illustration of how the map may appear on Jane's mobile phone.

Figure 3: View approaching the walking map above lake Molveno (N 46.14121 E 10.95814) (left) and the map itself (right).

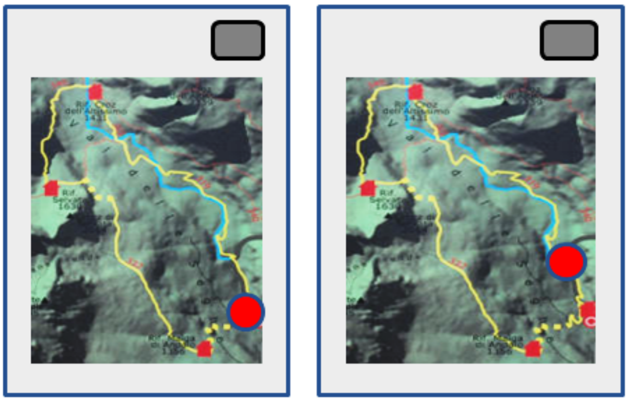

Figure 4: Map presented on the Fredo's phone while still standing in front on the physical map (left) and once Fredo has walked a short distance north (right).

HERE' *marker* in the map and the *vectorization* of the map to increase the handling when panning and zooming the map.

In the following we will discuss different approaches to encounter these challenges and discuss their advantages and limitations.

3.1 Visual Codes

if the 'YOU ARE HERE' maps are equipped with Visual Codes [9] or other 2D-barcodes, they can be easily used to perform the perspective correction and the georeferencing. Since the position and sizes of the codes are well known the procedure is straight forward and part of standard routines for marker-based augmented reality [6]. Depending on how much information can be stored in the markers, they can be used at the same time to either identify the map or to even store relevant information on the projection, scale and resolution of the map to enable a correct georeferencing of the image. If the marker contains only an ID, the relevant information has to be downloaded from an external source (e.g. a web service). Vectorization of the map is then easy, i.e. if additional digital map material of the area is available. However, this solution has a couple of drawbacks: Beside the restriction that the approach works only with maps equipped with markers, at least one of those visual markers has to be visible in the photo, which requires on larger maps (see Figure 2) either many markers or restricts the way the user has to take the photo of the map. Furthermore additional information needs to be downloaded to perform the georeferencing step.

In the second scenario we do not have to deal with the technical challenges we highlighted in the first scenario. For this approach we only have to tackle one challenge. Namely that the users have to georeference the map photo on her own. Following approaches are possible.

3.2 User Interaction

The distortion and georeferencing step can also be supported by the users themselves. Generally, if the projection of the map and the image distortion is not too complicated three known reference points can be enough to correctly geoereference the image. The reference points need to be given by the user and need to be combined with the current

GPS-coordinate provided from the GPS-module of the mobile phone. For this purpose the user needs to indicate her position on the photomap at least three times at sufficiently remote locations to obtain good results. This interaction can be triggered by the phone application while the user is moving. Directly after the user has taken the image of the map she should either indicate where she is on the map or the phone should find the 'You are here' marker to determine the actual user's position. After the user has moved a sufficient long way the phone should then request another indication of position from the user. The drawback of this solution is that depending on the projection of the map and the trajectory of the user, it may take a while until the georeferencing process produces useful results. Until then, users have no navigational support. Furthermore the system relies on the user to identify her position on the photomap during the georeferencing phase. Wrong answers most probably may result in a wrongly georeferenced map.

3.3 (Semi-)automatic GPS-based georeferencing

The optimal solution of course would be if the user interaction could be reduced to a minimum. For this purpose GPS-tracks recorded by the mobile phone before an after grabbing the photo can be used in the following way. If the system is able to identify the 'You are here' marker on the map (and thus connect a GPS-position to that marker) the user would just need to indicate a part of the trajectory he intends to follow on the map. If the device is equipped with a touch screen the user can directly draw on the Photomap, otherwise she might need to indicate way-points with the help of a crosshair. Once the use starts to move along that trajectory the system can compare the screen coordinates with the actual GPS-track recorded meanwhile the user is moving. Of course here it is assumed that the user stays on her way for at least the indicated trajectory. The big advantage here is that georeferencing starts immediately after the interaction and it is expected that quality of the georeferencing process increases with the overall travelled distance. It would be also possible to use the trajectory recorded before the encounter with the public sign, if the system can rely on additional street map data (which has been georeferenced before). Here the idea would be to use vectorization (see scenario 1) to identify the streetnetwork on the photomap and then try to align the resulting graph to the data recorded so far. In cases where the 'You are here' marker is in the centre of the map one could expect that the user had already travelled on streets visible on the map with the possibility to record GPS-tracks (this is not always true, for example if the user leaves a subway stop and encounters a 'You are here' map at the surface of the station). In some cases it might even be possible to integrate the streetnetwork on the Photomap completely into a given georeferenced street network. However this depends heavily on the type of map, the street details included and the quality of the reference data.

4. RELATED WORK

A thorough overview of mobile guides that rely on maps or map–like representations in providing their services is presented in [1]. The authors discuss technical issues as well as problems related to human factors that mobile guides have to cope with in order to assist their respective users.

One of the earliest deployed systems to provide mobile users with a digital map representation with a 'You are here' dot was the GUIDE system [3]. With this system, the user could request to view a sketch–like map of her surrounding area and if the user is currently using the system to navigate to a particular attraction then (in addition to providing a textual description) the system augments the displayed map with a simple animation to highlight the path that the user needs to take.

Figure 5: Example of vandalism to a 'You are here' type map in Florence, Italy.

Other researchers have addressed the combination of paper maps and mobile devices in several ways. Reilly et al. [7] use maps equipped with an array of RFID (Radio Frequency Identification) tags to realize the link to the paper map. This method was enhanced by using computer vision techniques [7], resulting in a higher spatial resolution and enabling more interaction techniques. MapSnapper (see: http://www.iam.ecs.soton.ac.uk/news/1038) is an application that takes a picture of a paper map and sends it to a central server for analysis. The resulting map, which is sent back to the user, contains details on all nearby personalized points of interest.

Schöning et al. [11] introduced a method that uses an optical marker for map interaction. This allows for the display of additional geoinformation, such as georeferenced vector or raster data, on the map. One disadvantage of this approach is that valuable map space is obscured. Subsequent work addressed this problem [8]: In order to align the overlay graphics with objects in the camera view, the video stream of the camera is continuously analyzed. The position of objects on the map has to be tracked in order to accurately align the graphical overlays with the real-world view. To simplify the task of real-time markerless tracking on a mobile phone with limited computing resources, the map is modified in our prototype setup: it contains black dots arranged in a regular tiny grid. Using the correlation between a precomputed map and the camera image, the system computes the actual position of the mobile device over the map. Using this technique we implemented Wikeye [5] & Wikear [10] as an approach to improve the understanding of places that combines digital Wikipedia content and paper-based maps.

From a slightly different perspective the approach described here can be considered, in part, as a form of Note taking [2] whereby a mobile user walks away with information that they believe will be of later utility.

5. CONCLUSION AND FUTURE WORK

In this paper, we have discussed two approaches of enabling a user to 'grab' a map shown on a public display by taking a photograph of it using her GPS enabled mobile phone (i.e. without the use of any ad–hoc networking, such as a Bluetooth file transfer). The map could be augmented with visual codes for communicating scale and geographic reference (such codes could also be used to represent the World file) of the 'You are here' position but this information should already be available from the GPS enabled phone. The mobile phone would be required to perform perspective correction and appropriate image recognition in order to produce and display a georeferenced map complete with 'You are here' indication. In our second solution no visual marker are need on the map. Users have to assist in an easy and intuitive way to do the georeferencing process as described in 3. Our current plan is to implement both systems (although if absolutely necessary some wizard-of-oz techniques may be used) and evaluate the suitability of the approach. Some of this evaluation will be formative but comparative evaluation may also be necessary, for example, how would this approach compare with using a 'google maps' type application on a mobile phone. The implementation and evaluation of this approach is novel and it is anticipated that a research paper would result from this work. The Nokia N95 will be used as the plattform for both scenarios. Unfortunately, an additional challenge for the approaches described in this paper is the vandalism that can occur to public signage. Figure 5 shows an example of such damage to a 'You are here' type map in the city of Florence, Italy and this example is certainly not rare. With a web 2.0 styled online map collection tool different users can collect, share and merge their PhotoMaps. With that we can adress the problem of vandalism by looking for *older* and undamaged PhotoMaps in the online map library.

6. ACKNOWLEDGMENTS

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