Augmenting Physical Maps: an AR Platform for Geographical Information Visualization

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Abstract

Physical maps of a city or region are important pieces of geographical information for tourists and local citizens. Unfortunately the amount of information that can be presented on a piece of paper is limited. In order to extend the map information we propose an augmented reality (AR) system, ARTourMap, for additional information visualization and interaction. This system provides an abstraction layer to develop applications based on the concept of separated logic map tiles taking advantage of a multi-target system where several regions of the map trigger different superimposed graphics. This allows the map to be folded, to be partially occluded, and to have dematerialized information. To demonstrate the proposed system ARTourMap, three layers were developed: a location-based game with points of interest (POIs), a 3D building visualization and an historical map layer.

Categories and Subject Descriptors (according to ACM CCS): I.3.3 [Computer Graphics]: Picture/Image Generation—Line and curve generation H.5.1 [Information Interface and Presentation]: Multimedia Information Systems—Artificial, augmented, and virtual realities

1. Introduction

In an age where every mobile device has a mapping system, physical paper maps still possess several important characteristics. They are widely available in touristic locations, they can be folded, scribbled and annotated on and do not require an internet connection or electrical power to operate. For many users they are still the preferred way of finding a point-of-interest. In this paper we propose a system to decrease the digital divide between physical paper maps and mobile applications. By taking advantage of Augmented Reality (AR) techniques [NCJC15] the proposed ARTourMap mobile system expands the city knowledge [TP12] by introducing 3D meshes and geo-referenced information on top of the paper map. The main goal of the system is to create an abstraction layer for applications to be displayed on top of the physical map. This will enhance the physical map with interactive games, virtual tour guides and context-sensitive information while maintaining the haptic and tactile features of the paper map.

2. Augmented Maps

The ARTourMap system is an AR graphical layer that enables the creation of location-based applications superimposed into physical maps. The AR applications will run in a mobile device with a camera. The user points the camera to a certain area of the map to visualize the AR information relevant to that same area. The system divides the map into squared sectors as seen in Figure 1. Each

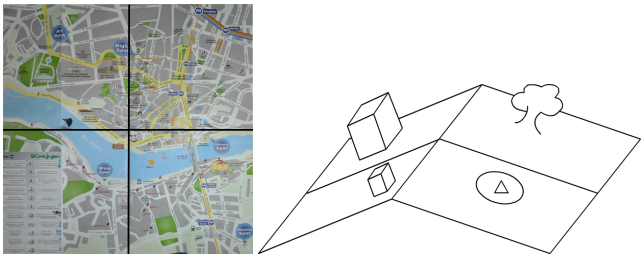

Figure 1: *a) Tourist map divided into four map tiles. b) Augmented reality content will follow the physical paper when rendered in the mobile device.*

section is only activated if it is visible in the camera. The rendering system is divided into several sections called:

$$MapTile_{ij} = \left\{ ARMarker_{ij}, Geometry_{ij}, geocoord_{ij} \right\}.$$

Each *MapTile* is associated with an $ARMarker_{ij}$ corresponding to a small section image of the map. The AR system (based in the Vuforia AR system) detects the image and super-imposes the associated $Geometry_{ij}$ into the screen. The AR system is programmed to track multiple markers at the same time. To detect a marker the system compares the image captured by the camera with a set of pre-programmed markers in the system (4×4 in our prototype). After detecting the marker the system keeps track of it, thus op-

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timizing the search for other markers. In the current implementation we found that tracking 4 markers at a time is sufficient for a close-up interaction experience. The *MapTile* is also associated with the geographic coordinates from that particular map section allowing the creation of location-based content. The final system is an abstraction layer that enables the introduction of virtual content based on GPS coordinates. Each mesh is automatically associated to a *MapTile* according to its world coordinates.

3. Applications

To demonstrate the ARTourMap system, three application layers were developed (using Unity3D) to take advantage of the *MapTiles*. The three application layers, seen in Figure 2, are:

- **Location-based game layer:** in this mode, seen in Figure 2a), the application explores the GPS position from the device [JC11] indicating the position of the user in the physical map and suggesting the exploration of touristic paths and stories [GFLT11].
- **3D layer:** through the usage of the GeoStream library [GJR*15], the application seen in Figure 2b), this layer downloads building information from OpenStreetMaps and extrapolates possible heights for the retrieved building footprints. It then performs an extrusion of each footprint in order to create an approximate 3D mesh. Each MapTile now has several 3D buildings placed in their real positions, giving the user a better vision of the dimension and content of the city [GJR*15].
- **Historical and Cultural Heritage:** this layer explores the connection between the current map and its 19th century counterpart allowing for an historical voyage through time. The tourist will be able to identify new streets that now exist and older streets that are no more. A slider that gently fades the old map over the current physical one allows for the tourist to better spot the cultural heritage [Hal11] points of interest and how to get there.

4. Final Remarks

The current prototype is being tested and is showing promising results. Informal testing shows that the AR layer improves the usefulness and the interest of the paper map.

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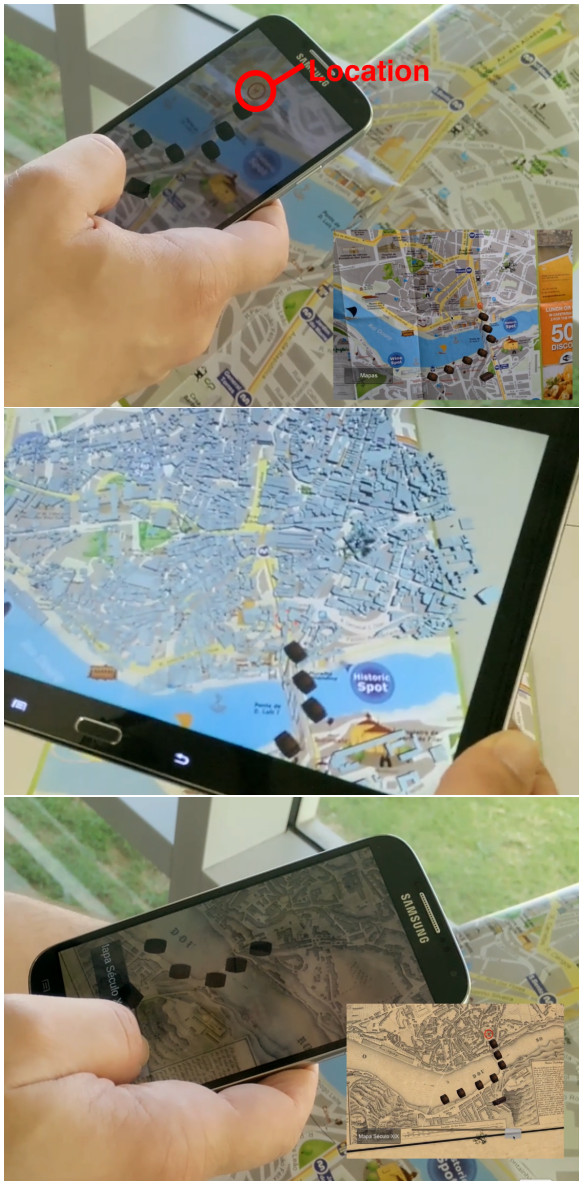

Figure 2: *ARTourMap applications using smartphones or tablets to visualize AR content: a) Location-based game. b) 3D city building visualization. c) Historical and Cultural Heritage layer.*

References

[GFLT11] GRETZEL U., FESENMAIER D. R., LEE Y. J., TUSSYADIAH I.: Narrating Tourist Experiences: The Role of New Media. In *Tourist Experiences: Contemporary Perspectives.* (2011), Routledge, pp. 171–182. 2

[GJR*15] GONÇALVES J. S., JACOB J., ROSSETTI R. J., COELHO A., RODRIGUES R.: An integrated framework for mobile-based ADAS simulation. In *Modeling Mobility with Open Data*. Springer International Publishing, 2015, pp. 171–186. 2

[Hal11] HALADOVA Z.: Reconstruction of cultural heritage object utilizing its paper model for augmented reality. In *Proceedings of Eurographics Conference 2011* (Llandudno, Wales, UK, 2011), Eurographics Association, pp. 7–8. 2

[JC11] JACOB J. A. T. P. N., COELHO A. F.: Issues in the Development of Location-Based Games. *International Journal of Computer Games Technology 2011* (2011), 1–7. 2

[NCJC15] NÓBREGA R., CABRAL D., JACUCCI G., COELHO A.: NARI: Natural augmented reality interface - interaction challenges for ar applications. In *Proceedings of the 10th International Conference on Computer Graphics Theory and Applications (VISIGRAPP 2015)* (2015), pp. 504–510. 1

[TP12] TAKEUCHI Y., PERLIN K.: ClayVision: The (elastic) image of the city. In *Proceedings of the 2012 ACM annual conference on Human Factors in Computing Systems (CHI '12)* (Austin, TX, USA, 2012), ACM, pp. 2411–2420. 1