# A MOBILE BROWSER FOR GEO-REFERENCED IMAGES USING AN ACCELEROMETER-BASED COMPASS

Francesco Massidda, Roberto Manca
*Geoweb and Mobile Experience Lab, Sardegna Ricerche, 09010 Pula , CA - Italy*

Davide Carboni
*CRS4, Parco Scientifico e Tecnologico Sardegna Ricerche, 09010 Pula CA - Italy*

Keywords: Mobile Photo Browsing, GPS, Compass, Accelerometers, Geo-Browsing, Maps.

Abstract: In this paper a new mobile browser for geo-referenced pictures is introduced. Based on common embedded GPS and accelerometer sensors, the implemented mobile browser is able to show tagged photos on the web, depending on the direction the user is facing to, allowing a positional-dependent touristic, commercial or cultural preview of our cities. A novel compass-simulator developed using build-in accelerometers data samples represents.

## 1 INTRODUCTION

One of the most promising usage of user generated content and metadata is the geo-referencing of multimedia objects in e-learning, environmental protection, tourism, culture and other application fields. Among the others, pictures perfectly meet the requirement of digital geo-referenced resources because photos always refer to well known places and times in/at which they have been taken. Furthermore, the release of worldwide known programming tools like the Google Maps API has fostered the development of a lot of geographical web applications and mashups (ProgrammableWeb).

Browsing large collections of geo-referenced photos is an emerging topic in research (Carboni et al., 2006). Some works focus on automatic categorization and classification of images (Sarvas et al., 2004) to improve usability and to provide the ability to capture images and events without the worries of adding tags and metadata. In (Shneiderman et al., 2004) a combination of photos annotation, browsing and sharing is proposed with the aim of supporting exploratory search. In World Explorer (Ahern et al., 2007) an aggregated representation of a place is performed getting geo-referenced photos from Flickr and displaying labels on the map/aerial photo to relate a place with a concept. The project "Degree Confluence" represents an attempt to tie images to the space (The degree confluence project).

Furthermore, even more mobile devices are able to browse digital image libraries, thanks to their large displays and internet connection capabilities (Bluetooth, Wi-Fi and 3G). However, traditional mobile picture browsers (Fig. 1), tend to use a static approach that is not suitable for large datasets, particularly when geo-referencing data are attached.

In this paper, authors present a novel picture browsing method, based on embedded GPS and acceleration sensors in order to create a dynamic browser able to collect, catalogue and view images from public web sites like panoramio.com, according to the geographical orientation of users carrying their mobile phones.

(a) (b) (c)

Figure 1: Mobile picture browsers (a), (b) use static navigation tools or smarter and dynamic approach (Nokia N95 mobile phone) (c).



Massidda F., Manca R. and Carboni D.
A MOBILE BROWSER FOR GEO-REFERENCED IMAGES USING AN ACCELEROMETER-BASED COMPASS.
DOI: 10.5220/0001840704310434
In *Proceedings of the Fifth International Conference on Web Information Systems and Technologies (WEBIST 2009)*, page
ISBN: 978-989-8111-81-4

## 2 MOBILE PICTURE BROWSING

An interesting approach to the visualization of geo-referenced pictures on desktop has been recently proposed by the authors (Carboni et al., 2008). furthermore, effective mobile-embedded technologies, like a digital compass should allow new scenarios and new interaction modalities for portable devices. Unfortunately, at the time we are writing the paper, mobile terminals with a digital compass embedded are very few: the Nokia 6210 Navigator and the old Nokia 5140i while, mobile phones with accelerometers sensors are, instead, very common Accelerometers have been used in the recent literature in many research and development fields: in medical applications, in the automation of the vehicular navigation, for shock protection systems, for Robots' guide automation and, finally, for human assistance in hazarding and dangerous working environments. In mobile applications the accelerometers are used to increase or improve the interaction or to speed up the textual input (Sung-Do Choi et al., 2006), (Wigdor et al., 2003).

## 3 THE ACCELEROMETER-BASED COMPASS SIMULATOR

To provide a view of surrounding points of interest based both on heading and position, the proposed system must be connected with the GPS system which main objective is to provide position and not to provide heading. Nevertheless, if a GPS sensor is moving fast enough, it is possible to sample two positions after a short time interval to determine the heading. Unfortunately this approach is not viable for slow pedestrian mobility. Using acceleration sensors to determine heading is a theoretical solution: the double integral of acceleration gives the space associated with a movement. This computation is not practicable on a mobile terminal and the implementation must take into account a model for user movements in order to manage the problem like a pattern recognition problem. To make this model as simple as possible we restrict the set of actions to:

- a 90° clockwise body rotation
- a 90° counter-clockwise body rotation
- a pause of stillness

Thus, the problem is now how to recognize in which of the three actions the actual movement falls. Noise always affects the samples from the sensors. We can divide noise into two categories: the first cause of noise is the user that cannot move exactly how the algorithm expects especially when the user is still. Stillness is not real stillness and little oscillations are perceived by the sensors, so it is difficult to determine if the body is rotating slowly or if simply the user believes to be still. The second cause of noise is in the sensor itself. Even if the sensor is really still, an offset is often visible.

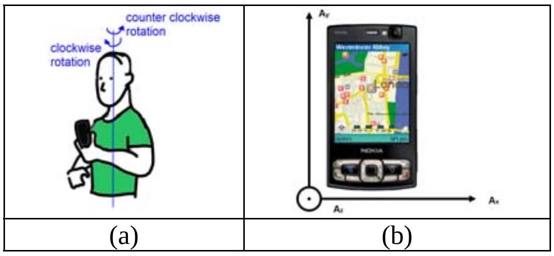


Figure 2: Reference coordinate systems for users (a) and accelerometers phone geometry (b).

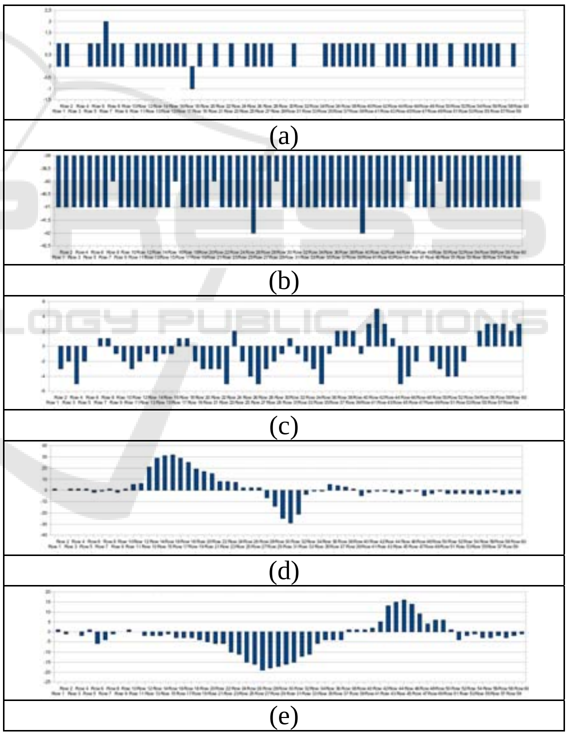


Figure 3: Samples from x-acceleration in different states: mobile terminal still (a), still but with offsets in one or more directions (b), with little oscillations (c), counter-clockwise (d) and clockwise movement (e).

First of all, lets define a common reference coordinate system as depicted in Fig. 2. It is possible to monitor and record acceleration data from a mobile terminal with sensor embedded: Fig. 3 shows some graphs related to the output data from the xcomponent of the acceleration,. It can be observe that there is a strong correlation between output data and one of the five possible observation patterns described above.

Using the chosen reference coordinate system, and simplifying the problem using only the x-axis data, it is possible to create a mathematical model that describes each expected and possible state. According to Fig. 3.(d) and Fig. 3.(e) and generalizing them, it is possible to create the relative (ideal) pattern functions of the x-axis data for a counter-clockwise and a clockwise rotation of the body with the following formulas:

$$S_{x,left} = a \cdot t \cdot \sin(1/t) + b \cdot t \cos(1/t) \tag{1}$$

$$S_{x,right} = -c \cdot t \cdot \sin(1/t) - d \cdot t \cos(1/t) \tag{2}$$

For $\Delta_t = [t_1, t_2]$. Where $\Delta_t$ is the interval size of the movement done by the user. At the same time, it is possible to define a formula for the still state:

$$S_{still}(t) \equiv 0 + \eta_0 + \eta_1 \tag{3}$$

Where the last two term are noise contribution respectively from offsets and user oscillations. Once defined the parameters, learned for each user in order to better fit the observed samples with one of the possible states, the system is ready to recognize movements. Samples are filtered by a set of matched filters. Matched filters are obtained by correlating the discretized known template functions with the observed signal in order to detect the presence of the template in the observation. Using a Maximum-A-Posteriori (MAP) criterion, the most probable state is chosen.

## 4 THE MOBILE PROTOTYPE

After the definition of both, the mathematical model describing the codebook of allowed movements and a MAP decision criterion, a prototype has been planned.

Despite of the achievable accuracy (in example increasing the number of cardinal points or using the three axis acceleration data), a basic prototype has been implemented. In particular, only the four main cardinal points have been considered (N,O,S,E).

The idea was that once started the application-browser, a set of pictures are always shown in the display. Which set of pictures must be drawn depends on the current GPS position and the current heading of the user. An embedded image set is available but the application is able to connect and browse geo-tagged pictures directly from panoramio database, all over the world. Every time the user changes its geographical orientation, the system draws (90° clockwise body rotation or 90° counter-clockwise body rotation) or not (pause of stillness) other five pictures, choosing them with respect to the estimated direction.

In order to assign different importance levels to the different areas closest to the user's location, a geographical map is considered and centered in the user position. The map is divided into four areas, starting from the central position ($P_{GPS}$) estimated by the GPS tracker (Fig. 4). Then, each area is further divided into three different sub-regions A, B, C. If almost five pictures exist in the A sub-region corresponding to the direction the user is facing to, these photos are displayed. Otherwise, remaining images are taken from the B sub-region and so on.


Figure 4: The partitioning scheme for the geographical maps.


Figure 5: A snapshot of the application on a Nokia N95.

When the user starts using the application, and sets the initial point, the pictures are displayed and the user can start rotating and looking photos representing places and things around him. A snapshot of the running prototype is shown in Fig 5. The Prototype application is freely available and downloadable in the authors' website.

## 5 EXPERIMENTAL TESTS AND RESULTS

In order to assess the compass simulator efficiency and the effectiveness of the mobile geo-browser, two preliminary tests have been developed. We used ten beta testers in each test: in the first experimental test (Table1), two different sessions were developed, using 40 and 80 accelerometer data samples per second. In both sessions, the software recorded computing times. In the second experimental test (Table 2), users were asked to answer a brief questionnaire with scores ranging from 1 (the worst) to 5 (the best).

Table 1: Hit Percentage and computational times for the accuracy tests. Mean times are computed in seconds.

| **Beta Testers** | **% Hit (40 samples)** | **Mean Times** | **% Hit (80 samples)** | **Mean Times** |
|---|---|---|---|---|
| User #1 | 93 | 0.604 | 97 | 0.837 |
| User #2 | 91 | 0.663 | 98 | 0.903 |
| User #3 | 88 | 0.597 | 98 | 0.881 |
| User #4 | 90 | 0.548 | 95 | 0.688 |
| User #5 | 95 | 0.615 | 97 | 0.753 |
| User #6 | 90 | 0.771 | 98 | 0.899 |
| User #7 | 93 | 0.659 | 97 | 0.932 |
| User #8 | 95 | 0.570 | 99 | 0.775 |
| User #9 | 92 | 0.588 | 94 | 0.874 |
| User #10 | 89 | 0.656 | 97 | 0.829 |

Table 2: Results of subjective tests.

| **Beta Testers** | **It is useful?** | **It works?** | **It is fast enough?** |
|---|---|---|---|
| User #1 | 4 | 4 | 5 |
| User #2 | 5 | 4 | 5 |
| User #3 | 3 | 3 | 4 |
| User #4 | 4 | 5 | 5 |
| User #5 | 4 | 4 | 4 |
| User #6 | 5 | 5 | 5 |
| User #7 | 5 | 4 | 4 |
| User #8 | 4 | 2 | 4 |
| User #9 | 5 | 4 | 4 |
| User #10 | 4 | 4 | 4 |

In Table 1, success hit percentages and computing times for the first experimental test are reported. Clearly, for all the users the hit percentage was always greater than 94% when 80 samples were used. Mean elaboration times increase with the number of samples but they still remain acceptable also for the 80 samples session.

The subjective experimental test, despite of its preliminary characteristic, seams to show a generalized positive assessment (Table 2).

## 6 CONCLUSIONS

In this paper a new mobile browser for geo-referenced pictures has been proposed. Accuracy results show that the accelerometers-based simulation technology works already well and users find very interesting and useful this type of applications. In order to make the prototype even more functional and effective, further developments are under study and planning, like the increasing of the accelerometer data rate, and the use of samples from all the three axis sensors. Next generation mobile terminals will be used to allow the real-time processing of this bigger amount of data. Extra capabilities like a map zoom-in/out function will be embedded in order to better define the areas interested by the selection of the images displayed on the mobile terminal.

## REFERENCES

ProgrammableWeb - Mashups, APIs, and the Web as Platform (http://programmableweb.com).

Sarvas, R., Herrarte, E., Wilhelm, A., and Davis, M. (June 06-09, 2004). *Metadata creation system for mobile images*, Proc. of the 2nd Int. Conference on Mobile Systems, Applications, and Services Boston, MA, USA, MobiSys '04. *ACM Press*, 36-48. New York, NY.

Shneiderman, B., Bederson, B. B., and Drucker, S. M. (Apr 04, 2004). *Find that photo!: interface strategies to annotate, browse, and share, Commun. ACM*, 49, 69-71.

Ahern, S., Naaman, M., Nair, R., and Yang, J. H. (June 18-23, 2007). *World explorer: visualizing aggregate data from unstructured text in geo-referenced collections*, In Proceedings of the 2007 Conference on Digital Libraries Vancouver, Canada, JCDL '07. *ACM Press*, 1-10. New York, NY,.

The degree confluence project. (http://www.confluence.org).

Carboni, D., Sanna, S., and Zanarini, P (September 12-15, 2006). *GeoPix: image retrieval on the geo web, from camera click to mouse click*, In Proceedings of the 8th Conference on Human-Computer interaction with Mobile Devices and Services, Helsinki, Finland. MobileHCI '06, vol. 159. *ACM Press*, 169-172. New York, NY.

Sung-Do Choi, Lee, A.S. Soo-Young Lee (August, 2006), On-Line Handwritten Character Recognition with 3D Accelerometer, 2006 IEEE International Conference on Information Acquisition, (pp. 845-850). Weihai.

Daniel Wigdor, Ravin Balakrishnan. *TiltText: Using Tilt for Text Input to Mobile Phones* (2003), Department of Computer Science, University of Toronto (www.dgp.toronto.edu).

D. Carboni, V. Marotto, F. Massidda, and P. Zanarini (September 10, 2008). *Fractal Browsing of Large Geo-Referenced Picture Sets*, 2nd International Workshop on Distributed Agent-based Retrieval Tools. Cagliari, Italy.