Augmented Reality for Mobile Devices: Textual Annotation of Outdoor Locations

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Abstract

For textual annotation of outdoor locations we propose in this paper an augmented reality method for mobile devices based on orientation and GPS measurements and uses a circular string of identifiers as data structure in order to determine what places are seen by the mobile camera. The proposed solution is generic and can be applied in all areas of the world if the required data are available (computed in off-line). The proposed solution has been implemented and served in our university campus for new students to discover all places.

Keywords: Augmented Reality; Mobile device; Textual Annotation; Outdoor Location; Circular String of Identifiers; Convex Hull.

1 Introduction

The aim of AR is the intertwinement of digital objects, texts and information with the ‘‘original’’ environment [Liberati, N. 2016]. Many AR applications have been developed for mobile devices and devoted to many subjects such as text document, adoption behavior, tourism, events, gamification, smart city, retail and cultural heritage.

Augmenting with text has attracted the interest of many researchers and many systems have been proposed such as the system of H. S. Ryu and H. Park [Ryu, H. S., Park, H., 2016] able to detect text documents in real scenes, to estimate their relative 3D poses to the camera, and to augment them with virtual contents.

Annotation in AR systems has been studied in [Wither, J. et al, 2009] showing its usefulness either for adding information in a direct or indirect manner. Many systems of augmented reality (AR) devoted for annotation of building, subway maps, and a museum have been proposed [Wither, J. et al 2009] [Eaddy, M. et al 2004] [Schmalstieg, D., Wagner, D. 2007]. For the proposed systems, many authors asserted than this orientation measurement is often deviated around tens degrees because of noise, jitter and temporal magnetic influences [Langlotz, T., 2011] and the presence in densely occluded urban environments which decreases the GPS accuracy, this imply that annotations will simply appear on the wrong location.

In other side, using computer vision for visual detection and localization need more advances of this area essentially for illumination changes and accuracy in feature extraction and matching with low complexity of computation needed for mobile devices.

Solutions for this problem have been proposed by several authors. The main idea is to generate panoramas from rotational motion of the device. The panorama is created in

a way that allowed users to annotate objects and to be shared with other users visiting the same spot as annotations anchor points were redetected in newly created panoramas by matching small image patches [Langlotz, T., 2010, Langlotz, T., 2011]. In similar work, AR system which allows to users to create content is proposed in [Langlotz, T., et al, (2012)]. To do this, authors propose two different approaches for tracking the device position: in a small workspaces using natural feature-based tracking of a known planar surface and in a large environment using GPS and panorama-based vision tracking.
Our goal is to avoid the complexity of computer vision techniques and the required accuracy for different tasks. We propose an efficient method of low complexity for textual annotating of places using a new concept: circular string of identifiers describing the 360° neighbor of the mobile device. The orientation, the GPS localization are used in order to define the arc of the circular string corresponding to what is seen. From the content of this arc, the annotation is displayed.
We implemented this method in our university campus for helping new students to discover all building and places.

In section 2 we describe the notion of circular string and how is used to infer the seen places. The section 3 explains the solution for taking into account the motion of the device and the appearance of new places around the device. We describe the obtained results in section 4. Finally, we conclude giving some possible improvements and future works.

2 Coding Seen Places Using Circular String of Identifiers

2.1 Basic principle

For a given position O representing the mobile device we associate on the map a circle (C) centred on O (see figure 1). Any place P_i surrounding the device that can be seen by the camera (when is fixing around it) is projected as an arc on the circle (C) labelled with an identifier (a character) which corresponds to a string annotating P_i.

The circle (C) is represented by a circular string "**SeenLocations**" of 360 identifiers. The identifier attached to each arc is duplicated **n** times, where **n** is the length of the arc. The starting identifier in **SeenLocations** coincides with the north direction and that whatever the radius of the drawn circle, the obtained string is the same because the lengths of the different arcs are the same (see the blue circle in figure 1). In the example of figure 1, the content of this string is:
SeenLocations = "**aaaa…..aaaa** *ffff…..ffff* **bbbb…..bbb** *ffff…..fff* **ccc….cccc** *ffff……ffffffff*", where **f** designates the no-annotated free space.
Note here that the dictionary of places (identifier, string for annotation) is build off-line for a given area.

2.2 Determining the seen places from

Once the azimuth angle β and the GPS coordinates have been obtained, the optical axis of the camera and the position of O are located on the map (see figure 2). The visible space is determined based on the angle β and the field of view $(-\alpha, +\alpha)$ of the camera. This allows defining a substring on the circular string which points either completely or partially to seen locations. On the string, the indexes of the substring are $\beta - \alpha, \beta + \alpha$. The displayed text will be the strings corresponding to each identifier of the arc. Depending on the content of the substring, the string is displayed as such or preceded by "part of".

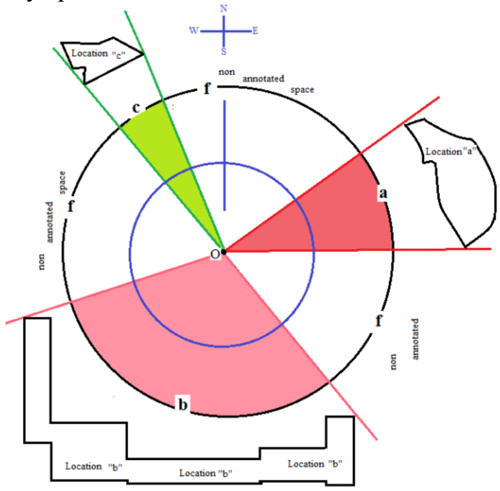

Fig. 1. The circular string of identifiers for a given location O composed here by the characters f(free space), a(location "a"), b(location "b"), c(location "c")

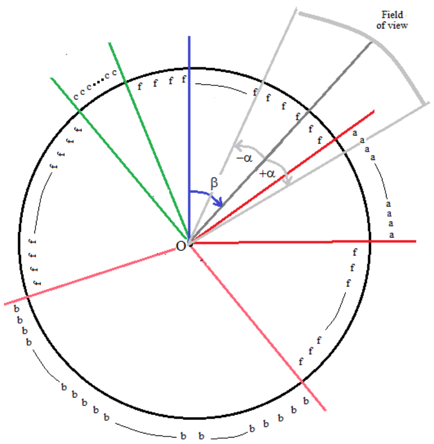

Fig. 2. Substring inference from azimuth angle β and field of view

3 Updating the Circular String for Moving Mobile Device

3.1 Updating without integrating new places

When the mobile device moves, the associated circular string must be modified because any selected substring of identifiers will not refer necessarily to the correct place. We assume that the device is moving from O to O' (see figure 3), the arc (mn) associated to the place P in the circle (C) corresponds to the arc $(m'n')$ on the circle (C') whose length and position may be different.

Let A, B be two of corners delimiting the place P. Let $m", n"$ be new located points on (C') at the same positions as m, n on (C). The arc $m"m'$ defines the angle α_m is equal to $\widehat{OAO'}$ which is computed using the distances $OO', O'A, OA$. In the same way, the arc $n"n'$ defines angle α_n equal to angle $\widehat{OBO'}$ which is computed using the distances $OO', O'B, OB$. Consequently, the positions of O, A, B, O' allows computing angles α_m , α_n and then the positions of m', n' corresponding to the seen place on the circular string.
The GPS coordinates of O, O' are communicated by the device (client) to the server, while those of corners A, B are assumed known (extracted and stored off-line from *OpenStreetMap* and Leaflet library). The content of the circular string is updated for each motion of the camera. The next algorithm describes the steps to be performed.

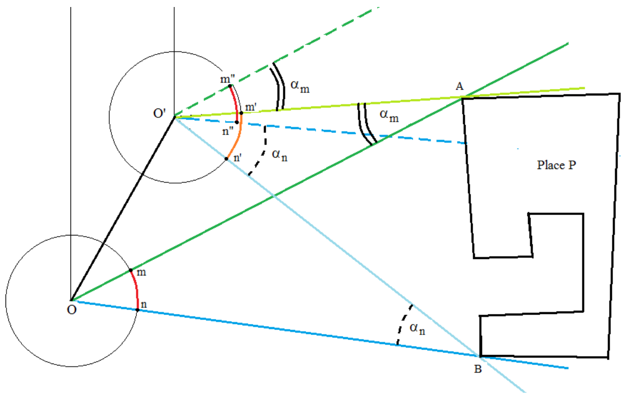

Fig. 3. Variation of the arc of view related to the mobile device motion

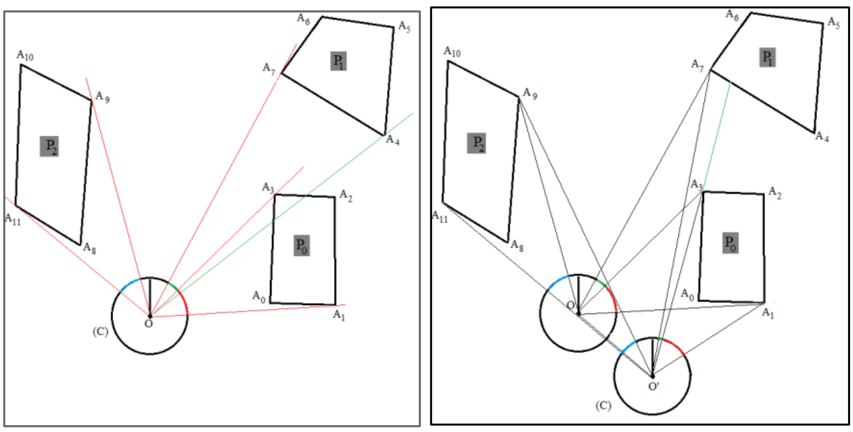

Fig. 4. Applying the algorithm 1 on the area of three places. (Left) initializing the circular string, (right) updating it

3.1.1 The algorithm

Let $\mathrm{P}_0, \mathrm{P}_1, \ldots., P_{k-1}$ be k places of a given area. $\mathrm{P}_i(\mathrm{A}_{\mathrm{i},0}, \mathrm{A}_{\mathrm{i},1}, \ldots., \mathrm{A}_{\mathrm{i,ni}}, id, Str_i)$ refers to the place P_i where $\mathrm{A}_{\mathrm{i},0}, \mathrm{A}_{\mathrm{i},1}, \ldots., \mathrm{A}_{\mathrm{i,ni}}$ define the corners of the convex hull encompassing it, Str_i is the annotation and id the referred identifier on the circular string. The algorithm 1 gives more details how the content of the circular string is updated (see figure 4).

Algorithm 1.
Begin
#Initializing the circular string SeenLocations[i]='f' for i=0 to 359.
For(i=0 to 359) $\mathrm{SeenLocations[i]} = \mathrm{'f'}$
For each place $\mathrm{P}_i(\mathrm{A}_{\mathrm{i},0}, \mathrm{A}_{\mathrm{i},1}, \ldots., \mathrm{A}_{\mathrm{i,ni}}, id, Str_i)$
{ ***For each*** corner $\mathrm{A}_{\mathrm{i,j}}$

{

- Compute the associated arc mn on the circle (C) using the rays $\mathrm{OA}_{\mathrm{i,j}}$.
- ***If*** $\exists l /\ OA_{i,l} \cap P_j \neq \emptyset$ such that P_j is near to (C) than P_i,
  Then consider the ray that links O to the corner of P_j and passes throughout P_i. ***EndIf***

}

\# Let (pos1, pos2) be the positions of the arc mn on (C).
For(i=pos1 to pos2) $\mathrm{SeenLocations[i]} =' \mathrm{id}'$
}

#Updating the circular string
#Let O' be the new position of the camera
For each arc mn of (C)associated to $\mathrm{P}_i(\mathrm{A}_{\mathrm{i},0}, \mathrm{A}_{\mathrm{i},1}, \ldots., \mathrm{A}_{\mathrm{i,ni}}, id, Str_i)$
{ #Let $\mathrm{A}_{\mathrm{i,l}}$, $\mathrm{A}_{\mathrm{i,r}}$ be the corners of projected on the arc mn on (C)

- Compute the new position m' on (C) located so that $mm' = \widehat{OA_{i,l}O'}$
- Compute the new position n' on (C)located so that $nn' = \widehat{OA_{i,r}O'}$
- ***If*** $\mathrm{A}_{\mathrm{i,l}}$ or $\mathrm{A}_{\mathrm{i,r}}$ is not a corner of P_i
  Then evaluate the new projection on (C)using the nearest place P_j.
  EndIf

\# Let (pos1, pos2) be the positions of the arc $\mathrm{m'n'}$ on (C).
For (i=pos1 to pos2) $\mathrm{SeenLocations[i]} =' \mathrm{id}$
}
End.

3.2 Updating with integration of new places

When the device is in the same area, it may be sufficient to update the circular string as explained in subsection 3.1. However, when it moves towards another area or when new convex hulls' segments appear, the content of the circular string must be changed by inserting the visible places. Depending on the convex hull encompassing the place P, and on the position of the device's centre O, the corner points of P which will be used are determined depending on the position of O related to convex hull (see figure 5). Let $C_{i,4}$, $C_{i,0}$, $C_{i,1}$ be three successive corner points of the convex hull, and let (Δ_0), (Δ_1) be the line defined respectively by ($C_{i,4}$, $C_{i,0}$), ($C_{i,0}$, $C_{i,1}$). If the centre O appertains the area delimited only by (Δ_0), (Δ_1) and $C_{i,0}$ (see figure 5), the corners seen are $C_{i,4}$, $C_{i,0}$, $C_{i,1}$. This reasoning is applied for the current position of the centre O and the area where is located. As example, if the device is in the area delimited by (Δ_1), (Δ_4), the corners $C_{i,3}$, $C_{i,4}$, $C_{i,0}$, $C_{i,1}$ are visible.

Our method allow then to infer the circular string giving the new GPS coordinates of the mobile device and the known GPS coordinates of the corner points of all places of the area considered.

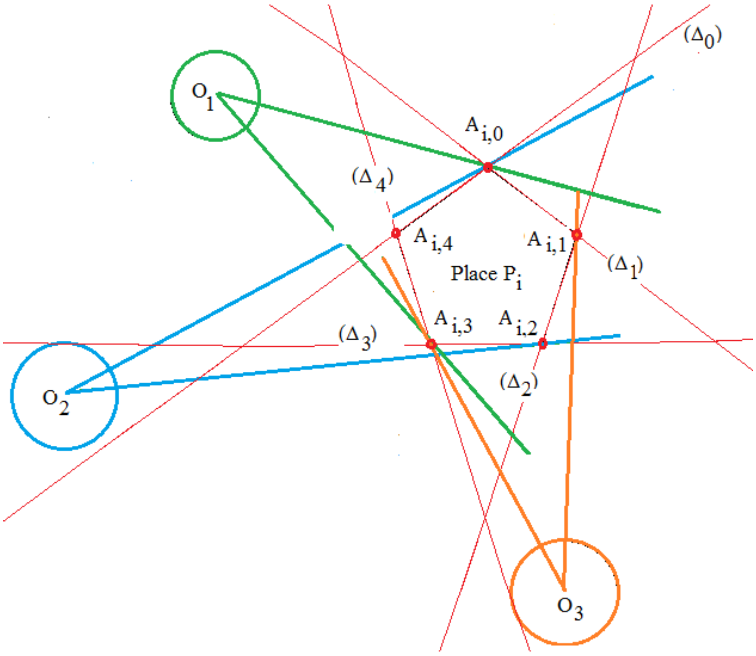

Fig. 5. Used corners in the computation of the arc of view.

4 Experiments and Results

We implemented the proposed method on mobile device under the system android. Some reference locations have been chosen in our university and the data related to the circular have been obtained manually and used as input data to the application. We show in figure 6 the map (one area of our university) obtained using the library Leaflet and *OpenStreetMap*. A reference point is chosen, the circle is drawn and the different arcs are determined. For each arc is associated an identifier (character) and the circular string is made using the lengths of these arcs. For each identifier is associated a text for annotation.
The selected views are illustrated by figure 7 where we can see the images annotated with correct text.

In order to avoid the instability of GPS measure which leads to instability of the text, we considered intervals of values instead of once value.

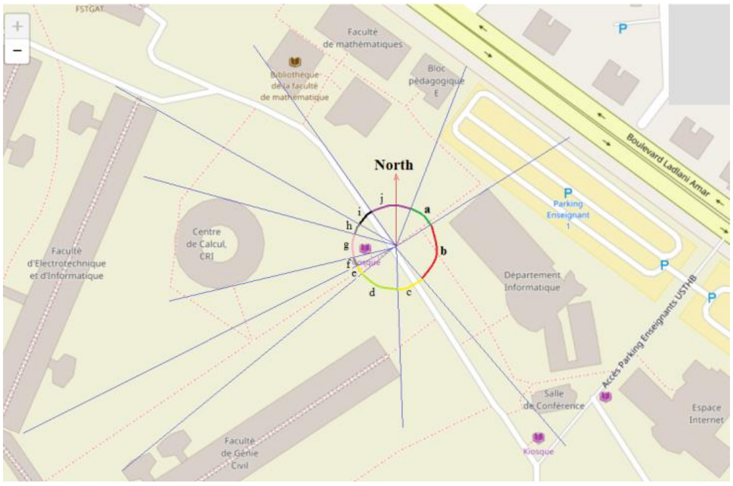

Fig. 6. The circular string of identifiers on the map for a selected reference point

5 Conclusion

We proposed a geometry based method for outdoor places annotation. Our method has been implemented and applied to our university campus and served for new students to discover using their mobile devices the different places without help.

The notion of circular string of identifiers introduced for coding the seen places has gave more efficiency to the application in the sense that it is easy to retrieve the places seen entirely or partially. This circular string is also updated for any motion of the device based on stored information of the area. Our next tasks are to deploy this method for tourism areas adding some text explaining the historical monuments and for annotating streets, buildings in any city of the world.

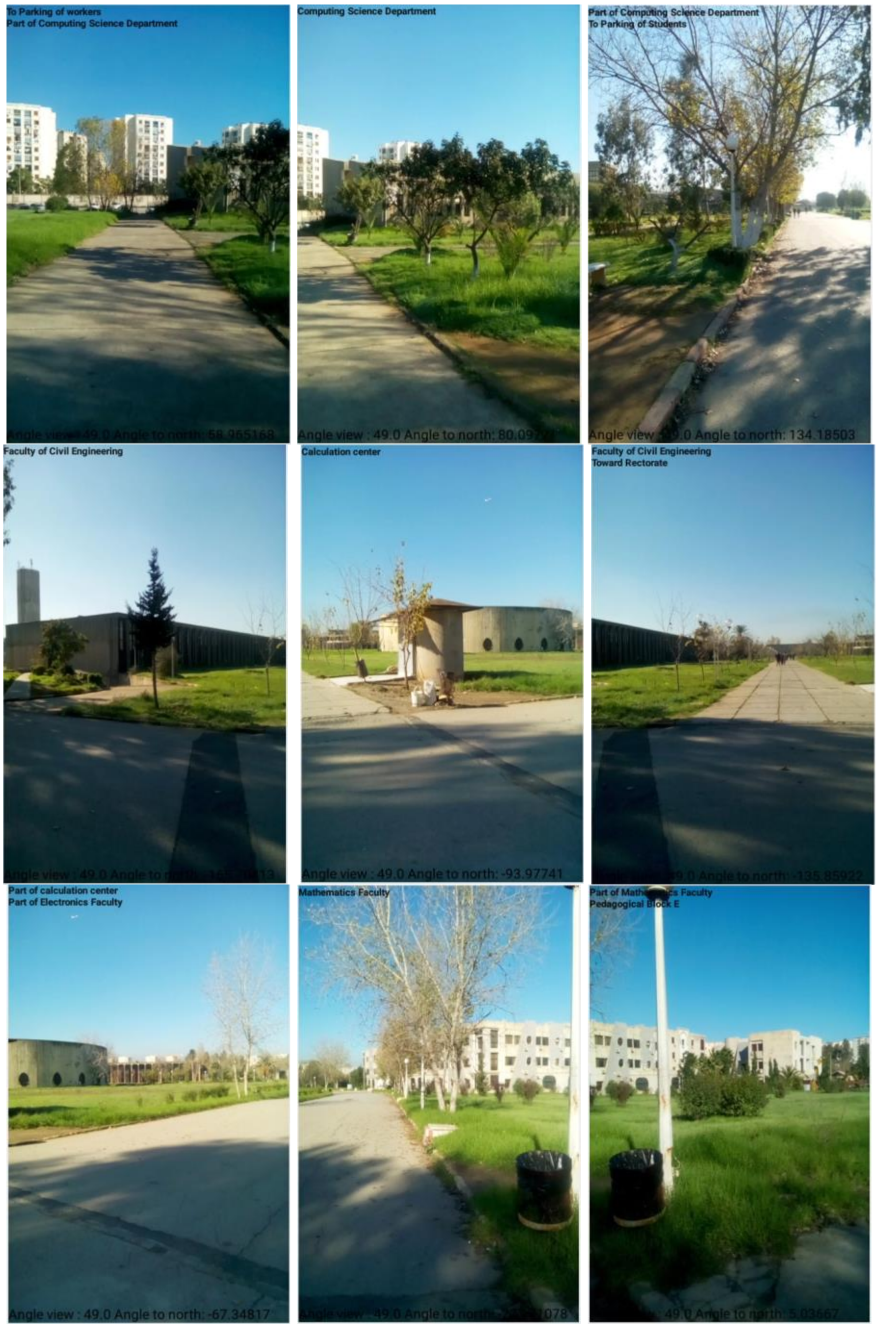

Fig. 7. The annotated locations

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