Using Urban Viewsheds for Embedding Geographical Context in Photograph Databases of Urban Areas

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1. Introduction

Architects, geographers, historians and landscape-planners are interested in understanding the changes in the morphology of urban forms and landscape (Joliveau and Dupuis 2006). An approach to analyse and visualise these morphological changes is based on the use of photographs, which are particularly useful in documenting the rapidly changing modern urban environments. With the advent of cheap digital cameras, photographs are routinely collected for various purposes such as post-cards, public works documents, newspapers, even at regular intervals for historical records. These collections of photographs are stored in dedicated photographic-database software, which generally do not provide the geographical context of the photograph thus it remains unknown exactly which parts (i.e. buildings, streets so on) of the city have been recorded in a photograph. The geographical context of a photograph allows the development of systematic and automated approaches to record the changes in urban form.

The geo-referencing of a photograph requires three main types of information about the photograph, namely the camera location, camera Field of View (FOV), and the camera azimuth i.e. the geographic orientation of the photograph. In the vast number of current and old photographs, the location of the camera is recorded manually on a map however some modern cameras which have built-in GPS can usually automatically retrieve this information, except in dense built-up areas where the GPS reception can be poor. Photographs taken from the air necessarily require a GPS or some other geo-referencing technique. The derivation of the camera FOV is relatively straightforward since it is directly related to the current focal length of the camera lens. The geographic orientation of the photograph is derived manually using a compass. In case of modern digital cameras, these three types of information are often stored in the Exchangeable Image File Format or EXIF[1] (only focal length) or the GPS Exchange Format or GPX[2] (except orientation) tags of digital photograph file however information on photographs

[1] More information on EXIF is available at www.exif.org (last accessed on 24th April 2007)
[2] More information on GPX is available at www.topografix.com/gpx.asp (last accessed on 24th April 2007)

taken from other kinds of cameras have to be manually recorded. Even after one has been able to record these thee types of information about the photograph, a manual identification of the urban features visible in a photograph can be a tedious and imprecise process when dealing with hundreds of photographs and the complicated urban layout.

This paper demonstrates the novel use of the concept of urban viewsheds in automatically identifying the urban features given the camera location, camera FOV and camera azimuth of the photographs.

2. Methodology and Results

An urban viewshed or isovist is the area visible from a viewpoint (Benedikt 1979). The procedure to identify the urban features visible in a photograph involves the following two steps:

Step 1 Generate the isovist at the viewpoint of the camera

Given the outlines of the buildings or building footprints, camera location (recorded by GPS etc.), camera FOV and camera orientation, the isovist of the camera viewpoint is generated using Isovist Analyst[3], an ArcView® GIS developed by Sanjay Rana. In the case of 2D open space, the isovist is naturally a 2D polygon as shown in Fig. 1

Step 2 Perform Spatial Overlap Query to identify urban features

Given the isovist polygon, building footprints (with attached attributes such as names) and in fact any kind of 2D geospatial data with relevant attributes, it is trivial to perform various spatial overlap query to establish the geographical context of the photographs and objects visible from the photographs. For instance, one could find all the photographs in the database which are supposed to represent the façade of a particular building. Fig. 1 shows the isovists of various camera viewpoints in a part of central Lyon (France). Fig. 2 shows the results of an overlap query on identifying the photographs that contained the building shaded red. Specifically, the spatial query essentially involves the search of all isovist polygons that intersect the building polygon shaded red. Now since, each isovist polygon is associated or joined (in database terminology) to a photograph, it is straightforward to retrieve the photographs that contain a view of the particular buildings.

3. Future Work

In the present work, we have demonstrated the application of 2D urban viewsheds or isovists in querying the geographical context of photographs. However, photographs capture a 3D representation of the urban forms therefore we intend to generate 3D isovists while expecting to deal with some non-trivial computation geometry in performing 3D overlap queries.

4. References

Benedikt ML, 1979, To take hold of space: isovists and isovist fields. *Environment and Planning B*, 6, 47-65.

Joliveau T and Dupuis B, 2006, Conception et Utilisation de Visualisations Numériques pour la Gestion Paysagère. *Revue Internationale de Géomatique* (*European Journal of GIS and Spatial Analysis*), 16, 115-134.

[3] Download Isovist Analyst at http://www.ucl.ac.uk/~ucessan/

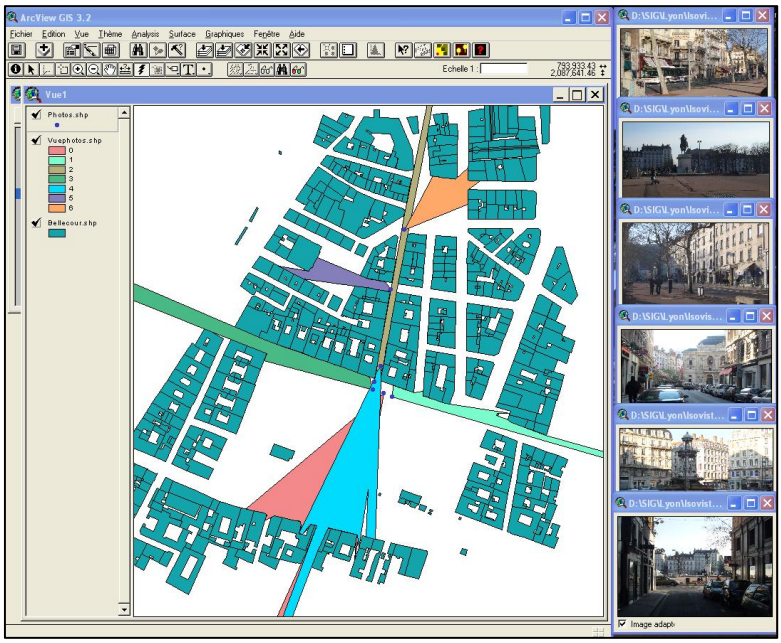

Figure 1. Photographs and their respective isovists in a part of Lyon, France. The small discs between the building blocks and the polygons extruding from these discs are respectively the location of the camera and isovists.

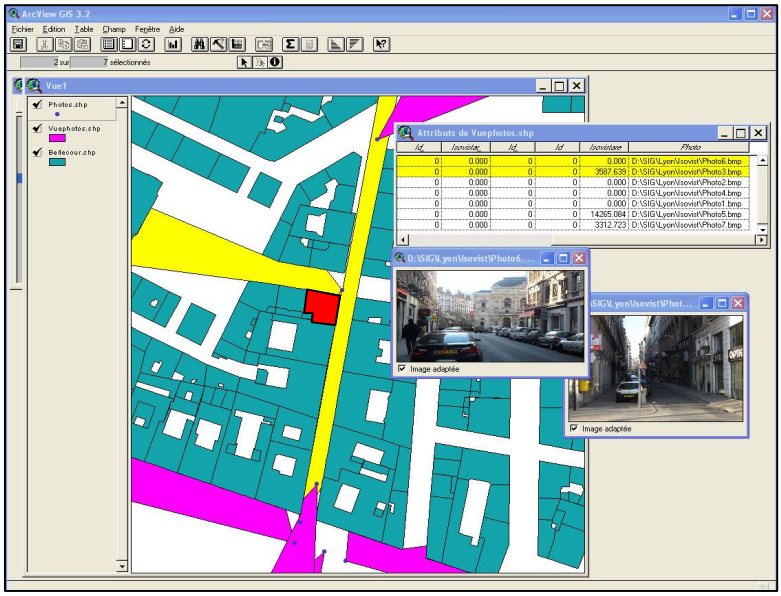

Figure 2. Automatic retrieval of the two photographs that contain a view of the building shaded red, using spatial overlap between isovists and building polygons.