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Junjun Yin

*Technological University Dublin, junjun.yin@tudublin.ie*

James Carswell

*Technological University Dublin, james.carswell@tudublin.ie*

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# MobiSpatial: Open Source for Mobile Spatial Interaction

Junjun Yin  
Digital Media Centre  
Dublin Institute of Technology  
Aungier St., Dublin, Ireland  
yinjunjun@gmail.com

James D. Carswell  
Digital Media Centre  
Dublin Institute of Technology  
Aungier St., Dublin, Ireland  
jcarswell@dit.ie

## Abstract

This paper describes our Mobile Spatial Interaction (MSI) prototype *MobiSpatial*, which benefits from location and orientation aware smartphones and existing open source spatial data initiatives to facilitate user interaction with the geospatial query process. We utilize today's ubiquitous mobile device as the central computing platform to calculate a mobile user's visibility shape at his/her current location. *MobiSpatial* uses this shape as a query "window" in a spatial database to perform line-of-sight, field-of-view and 360° Isovist visibility searches. These visibility based spatial queries reduce the risk of "information overload" by exploiting "hidden query removal" functionality to retrieve only those objects that a user can actually see. By incorporating open source datasets and databases, our application manages to store, index, query, retrieve, and display spatial information solely on the mobile device itself, without concern for any server side computations or internet connections.

## Keywords

Mobile Spatial Interaction, Open Source, GeoProcessing Web

## 1. INTRODUCTION

Today's new generation smartphones are rapidly evolving as enhanced computing platforms in terms of hardware/software specifications and capabilities (e.g., more powerful CPU, larger RAM/storage capacity, touch screen interfaces, etc.). In particular, a noticeable trend of integrating location and orientation aware sensors (i.e., GPS receiver, digital compass and accelerometer), into mobile devices has significantly promoted the development of applications for mobile spatial interaction (MSI). For instance, "show me all the cafes within 1 km" or "show me any nearby social network events posted within 1 hr". Using *mashup-maps* is a popular approach for these LBS services, where the results from each particular user request are displayed as annotations overlaid on top of base mobile maps. Mobile maps help users to keep track of their *spatial context* and are now usually preloaded in the mobile device, such as Ovi Maps for Nokia phones and Google Maps for Android phones and iPhones, etc.

Spatial proximity queries are one of most popular query types

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available for mobile users and have been implemented by many location based service providers, such as Google Maps, Bing Maps, and GeoNames, etc. However, such an approach has triggered two significant usability concerns:

Firstly, most existing mobile maps, such as Google Maps and Bing Maps are provided and controlled by commercial data providers. This constrains the freedom of developers to access the original map data for advanced data handling (e.g., visualization and geometry manipulation). Also, the map data coverage over certain areas can still be of considerably poor quality and extent – especially in less populated areas. In this case, any retrieved results are annotated and populated on top of outdated mobile maps, leading to the *spatial context* becoming vague and hence adding to users getting further disoriented.

Secondly, many LBS services limit their query process to search shapes that are either a bounding box or a circle - a type of range (proximity) query that determines whether those geometries (e.g. building *footprints*) have the "within" topological relationship when compared to the source query shape [1]. However, due to the all encompassing nature of searching using a bounding box or circle, as well as ever increasing amounts of available spatial data, a data visualisation problem arises as the number of returned results from this type of query can be overwhelming for these devices and their users alike. Constrained by the relatively small screen size of mobile devices, "display clutter" or "information overload" becomes a significant problem. This can also cause confusion and disorientation for users, and general annoyance and apathy towards the usefulness of any LBS application.

A potential solution to these issues is to exploit existing open source spatial data initiatives. In particular, with regards to the availability and completeness of existing mobile maps, there is a rising interest in contributing "volunteered geographic information" (VGI) to enhance the amount of accessible geographical data resources on the Web [2]. One of the more successful VGI projects is OpenStreetMap (OSM) [3], where growing detailed geospatial datasets are provided by volunteers and are free for public access. More importantly, because of granted access to large amounts of geospatial data from collective efforts, various other emerging open source projects are making efforts to enable OSM as their native mobile maps. For example, Route-Me [4] is an open source project for integrating OSM for both online and offline use in iPhone; TileMill [5] creates and stores map tiles from OSM data locally on the mobile device.

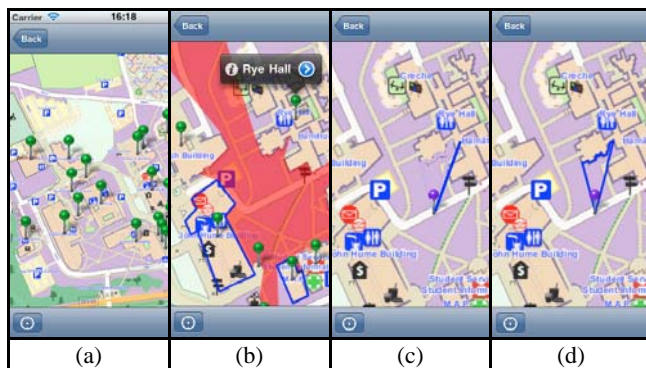
Until now, the major reason for many MSI applications to adopt "client-server" architectures is due to the lack of an efficient and lightweight spatial database management system (DBMS) available for mobile devices. However, the open source project, SpatialLite [6], which is a lightweight spatial DBMS built on top

of SQLite, can be ported and run efficiently on mobile devices. With the support of SpatiaLite, spatial data can now be stored in native data formats and indexed by R-tree for efficient query processing. Taken together, both these open source initiatives plus recent improvements in power/storage capabilities of today's smartphones have opened many new opportunities for standalone MSI applications research.

In this regard, *MobiSpatial* is our prototype MSI application designed to facilitate human interaction with the geospatial query process by determining the true shape of the actual visibility space for a user as a 2D query "window" in a spatial database, i.e., with line-of-sight, field-of-view, and 2D Isovist for 360° visibility queries. With these visibility based query shapes, our application provides "hidden query removal" functionality where only those objects that users can actually see get returned from the search process. More importantly, we employ the mobile device as the main computing platform and incorporate a collection of open source initiatives that allow for data storage, display and spatial query processing all on the device itself. This differs from usual "client-server" architectures where mobile devices send requests and receive responses from web-servers and spatial query efficiency is highly dependent on the latency of Internet connections. Instead, our application employs a next generation LBS oriented "push-notification" architecture [7], where *MobiSpatial* updates new information to the device when available (e.g., local events, map content, etc.), via Wi-Fi connections. For more details on the *MobiSpatial* sw architecture, the reader is referred to [8].

## 2. A CASE STUDY ON IPHONE

This section describes the *MobiSpatial* prototype working on iPhone 3GS. The geometry data is downloaded directly from OSM, which covers our NUIM test area and its surroundings with over 2,000 geometry features including buildings, streets, and Poles. A display of building outlines and other geometries in this dataset is shown in Figure 1(a). The returned results from a 2D Isovist query (Figure 1(b)) are annotated as pins on top of the base map, where a selection on each pin will draw its corresponding geometry on the mobile map or link the user to more relevant web-based information. Example shapes for "line-of-sight" and "field-of-view" queries are shown in Figure 1(c) and Figure 1(d) respectively. All the geometries are pulled from locally stored records in SpatiaLite without the need for Internet connections.



**Figure 1:** (a) All OSM derived building centroids annotated as pins (b) Query results returned using "Isovist" query shape (c) A "line-of-sight" query shape (d) A "field-of-view" query shape

As shown in Figure 1(a), a local environment is overloaded with various buildings, where a conventional proximity query using a bounding box or circle cannot rule out those objects that are invisible to the user. However, as shown in Figure 1(b), adopting a user's 360° degree visibility (i.e., an Isovist view) as a search space can efficiently filter out those objects that users cannot see to reduce the risk of information overload and display clutter. The line-of-sight and field-of-view queries consider a user's facing direction. All three approaches promote human interaction with the spatial query process by retrieving only objects of either visual or directional interest to the user.

## 3. CONCLUSIONS

This paper describes our prototype MSI application *MobiSpatial*, which benefits from the location and orientation awareness of today's smartphones and existing open source spatial data initiatives to facilitate human interactions with the geospatial query process. Different from other MSI applications, *MobiSpatial* operates as a standalone mobile application by storing all data, including built environment footprints and map tiles, in an embedded spatial database on the mobile device, as well as performing locally all visibility calculations for spatial query processing. Such an approach allows for performing spatial queries on-the-fly while a user is moving through their physical environment without the latency/cost effects of mobile networks and "client-server" architectures.

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