Filtering Location-Based Information Based on Visibility in the Real World

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ABSTRACT
Although mobile, ubiquitous or mixed-reality systems may exploit tracking information for context, they rarely incorporate knowledge of the geometric configuration of the space. We have augmented a tourist guide system, the George Square system, with a visibility-filtering algorithm that can use knowledge about the actual buildings in the environment to cull away information about objects that the user probably cannot see from their current location.

Keywords
Mobile ubiquitous system, visibility filtering, context awareness

INTRODUCTION
Many mobile, ubiquitous or mixed-reality systems track users and use this information to define the context of the user and trigger application events [1, 2, 3, 4]. A tracking system might generate symbolic locations such as “In the UCL Front Quad” or a position in a coordinate system such as “latitude: 51:31:29N longitude: 0:08:05W”. Such location information can be then be used to query databases of geo-located data. A typical query might be “Find me all the coffee shops within 500m of my current location”. Such a query might generate the result of populating a map on a hand-held PDA with icons representing the locations of nearby coffee shops, and perhaps directions to the nearest of these.

Although such an application would be mobile and context aware, it ignores one of the fundamental properties of the situation: the actual configuration of buildings around the user. The geo-located information refers to objects in the environment or to regions of space, and those objects and regions may or may not be visible to the user. Whether they are visible or not will be of critical importance to the user because such knowledge greatly simplifies navigation about the environment.

We have extended an existing mobile, map-based tourist system, the George Square system, built as part of the City project of Equator. The George Square system tracks activity of multiple users in the environment and uses this as the basis of a recommender system that suggests places to visit [5]. Figure 1 shows an example view of a map within the George Square system.

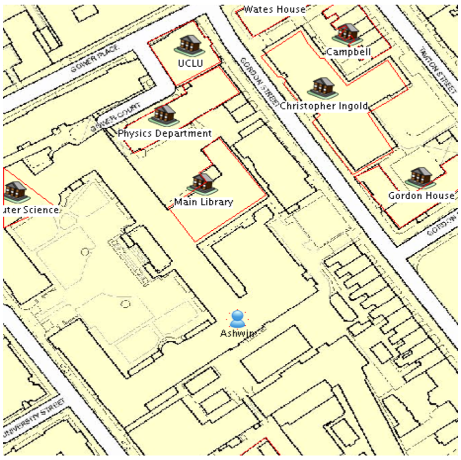

Figure 1 A map from the George Square system showing a user, and a selection of icons for recommendations

GEORGE SQUARE SYSTEM
In the George Square system, a service called Recer generates recommendations at regular intervals from the database of past users paths.

A recommendation can be in the form of an image, place or a URL. Some recommendations are created initially when the system is setup. Thereafter, each visitor adds to the recommendation. New places cannot be created by the visitors - they can only upload images and URLs which get associated with a particular place.

The service uses the Recer collaborative filtering algorithm that matches a user's recent activity with similar past periods on activity in the database [6], and drawing locations and URLs from these periods. Currently, this service is designed to recommend a set number of web pages, places and photographs from past visits.

We have extended the George Square system to apply visibility processing to prioritize recommendations that are probably visible to the user.

VISIBILITY-BASED RECER
Focus Points
When the system is initialised, it is primed with information about places of interest, referred to as Focus

Points in the Recer system. The region bounding the places of interest is represented in the form of a polygon. A Recer editor has been developed such that these boundaries can be directly 'drawn' on the map during initialization phase.

Visibility Computation

The visibility of a focus point is computed as follows. A set of points which lie within the bounding region of a focus point is randomly selected. This set is referred to as the target set. Another set of points, known as the viewpoint set, is selected, such that the points are near the viewpoint. The size of the viewpoint set can reflect the uncertainty in location information.

Rays are cast from each point in the viewpoint set to a point in the target set. If a ray does not cross any building on its path, it is considered to be a visible ray, otherwise it is an invisible ray. The percentage of visible rays for a given pair of set determines the visibility confidence of the focus point. Figure 2 demonstrates how this works. The ratio of thick lines vs. thin lines determines the visibility confidence.

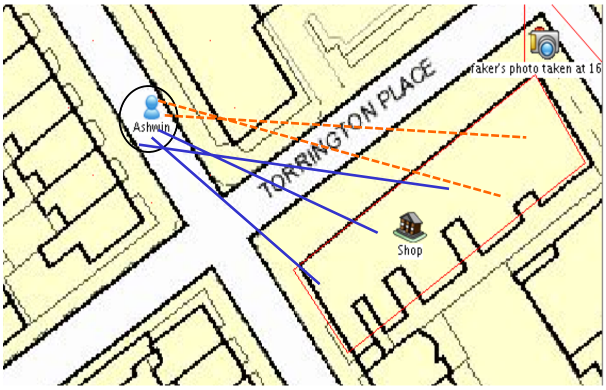

Figure 2 Rays from the viewpoint to the target are selected at random to estimate the confidence of seeing the target

This visibility confidence allows for cheap and rapid computation, whilst introducing flexibility in the system. It allows the Recer to introduce other criteria before recommending a focus point. For instance, a partially visible or occluded focus point may be of great interest, though not visible from the current view position. The Recer may decide that it should anyway be recommended.

Visibility Filter in the Recer Service

At regular intervals, the Recer service generates recommendations. It considers recommendations within a distance around the user. The visibility of the recommendation is computed using the previously mentioned algorithm. The user then receives recommendations of items that can be spotted from his location. Figure 3 shows the overall system architecture.

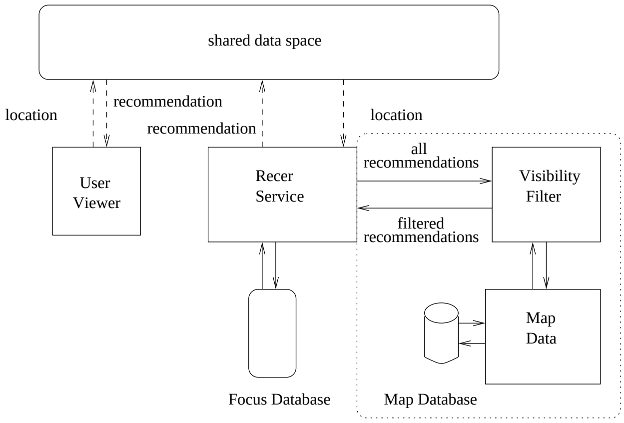

Figure 3 Overview of system architecture for visibility-enhanced George Square system

CURRENT AND FUTURE WORK

The notion of exploiting configuration of space in controlling application behaviour has been suggested previously in the literature (for example [7]). Our system is one of the first attempts at exploiting more real-world knowledge, in the form of actual building shapes, in a context-aware application

It is envisaged that the creation of region bounding geographical features, such as buildings, parks, etc will be automated using map information in the Ordnance Survey MasterMap format [8]. The map image displayed on the user interface can be generated using mapserver [9]. Together these extensions will mean that the system can be easily deployed anywhere in the UK.

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