Search and Navigation in Complex Overlapping Urban Spaces

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Abstract
Experiencing a city is different from panning over a map. Maps are powerful abstractions that cannot cover all aspects in dense and complex urban spaces where a lot of buildup, overlap, tunneling, underground and overground transportation is situated. In exploring such urban spaces, we explore the full dimensionality the city has to offer. This is an issue of both an added elevation dimension and the interaction and visualization with such enriched data about the city. In this paper we explore visualization and exploration aspects and discuss initial ideas.

Author Keywords
Geospatial Data; Urban spaces; Mapping; Navigation; Orientation

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Introduction
Most maps in use paint a very clear, yet flat picture of urban spaces. Maps are of course abstractions, but they need not stay flat to be useful. There are a few, not well-examined cases where this easy abstraction shows its limitations.

Overlap?

We define overlap as one geospatial feature that is on top of another. Simple examples are multiple floors on buildings, underpasses, subways, bridges, or tunnels. Stairs, elevators, escalators, or sloped streets connect and make these places accessible. Overlap in this form can occur within the city, but also within a building or in the interplay of multiple buildings or structures.

For example, navigation systems increasingly make use of detailed city models of various buildings to provide the visual cues of driving or walking through urban canyons. However, these are mostly decoration and cannot be accessed themselves. They remind of early computer games with painted-on non-functional doors. We expect this to change rapidly in the future. Already we see Google Streetview imagery from the inside of buildings.

While many residents know their way around, tourist may sometimes stop to look at high rises and wonder about their contents. Additionally, these may not only contain interesting places on ground level, but also higher up [8]. As another example to make use of urban landscapes, Blinkenlights turns facades of high-rises into screens [11].

When looking at aerial images, we see high-rises sometimes obscuring the view of some streets, but similarly receive a side view of the building that may enable us to judge its height. In the mountains or hilly areas, there is not direct overlap, but still a more laborious ascent to higher terrain. This often reflects in the street layout, which a practiced observer can use to infer contour lines.

Geographical Information Systems (GIS) have been doing this for a long time, managing streets, buildings, cables, sewers, electricity etc. or geological formations deep into the earth. As such, the third dimension is not new, but on most user-oriented maps, the visualization of points or regions of interest is still predominantly 2D or 2.5D.

Coming back to the city, some gems of urban exploration are hidden away in alleys or backyards. Some more are even better hidden in underground tunnels, crossings of tunnels, bridges, and streets, or on the 12th floor or the top of a high-rise. Even finding such places can be an important part of getting lost as a mode of urban discovery [10].

Yet, moving at ground level is the normal mode of transportation. We are rather good at walking around on the surface of the earth, but going up is a challenge. This can be exemplified by the fact that even while we routinely cover large distances, average houses are less than 100m in height and even most of the largest structures top out below 500m.

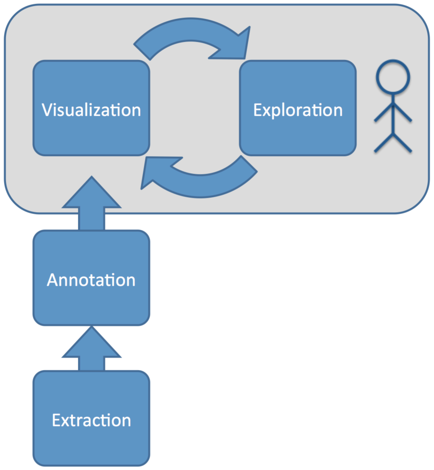

Figure 1. Data processing and user interaction

Still, the exploration of the heights (and depths) of the city and its buildings are a very interesting topic that deserves deeper consideration in both extraction and

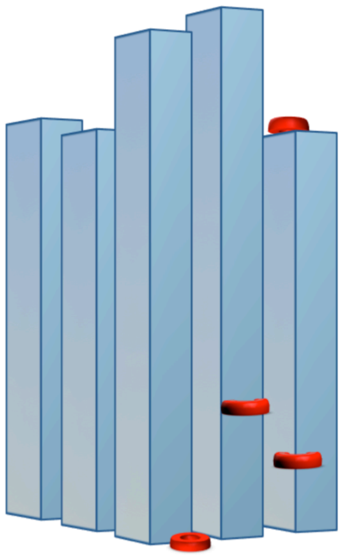

Figure 2. Mockup of POIs in an urban landscape

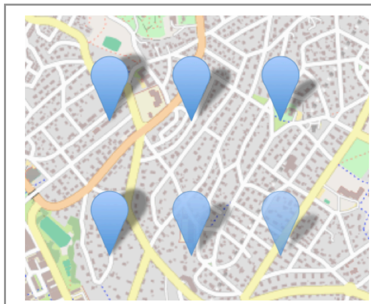

Figure 3. Mockup of map markers showing different heights

indexing of such data as well as search, visualization, and interaction.

Approach

For our initial examinations, we focus on the interaction side of local search [1]. Figure 1 shows a basic information retrieval approach necessary to support the modeling of complex spaces, starting from extraction and annotation of respective relevant data, up to a visualization and interaction process targeted towards the users.

Challenges include the processing and display of imprecise geo information [3] as a function of the granularity and precision of geospatial data. It will provide a way to explore the opportunities of geospatial context [2] further and examine 3D or other visualizations. As a special case, where not even 'down' is propery defined, the International Space Station (ISS) provides special challenges to orientation and navigation [7]. Previous work was concerned with displaying multiple Points of Interest (POIs) with the same location in one space on a map [4,8]. In our approach, we include these assumptions, e.g., in case of buildings that house multiple POIs on different floors. Decluttering multiple POIs at the same position, i.e., making them distinguishable on a map, can be aided with the additional altitude dimension.

As an initial approach towards visualization of the idea and a mockup of data distributions, Figure 2 shows a view of some high rises with different POIs, one on street level, on the top floor, and two in the middle. Figure 3 shows a more traditional mockup of usual map markers. In this case, it was aimed to visualize the height with a combination of shadow modification (first row) and added transparency (second row) to give a floating appearance. The strength of the floating effect can be adapted to vary according to the current zoom level. An interesting follow-up question would be a more formal development and classification of visualization methods and the ease of understanding them. For example, there is a difference in the markers on the 2D map, but an exact height relation may be difficult for users to make out. Also, the decluttering issue is not yet solved in this case, which mandates to better explore how a transition between 2D and 3D views may facilitate this. For example, on high zoom levels, some Local Search Engines now have 45° bird's view imagery available, which would make an adapted use of the marker approach feasible. For mobile users, overlays in the form of augmented reality [9] may facilitate visualizations as in Figure 2. Similar techniques may be used to find POIs that are outside the view [5].

There is a distinction to be drawn between local search [1] and navigation as a tool for exploration. For hyperlocal settings, such as navigation inside a mall, office tower, or cruise ship, tools such as stacked or exploded maps of the different floors can be used. Yet these do not scale up to a city. Additionally, they only provide a close-up view of areas of high point density. Such maps of buildings with mostly empty floors would also not be suitable.

A special area of interest lies in the combination of conceptual, cognitive, and geospatial maps that have some contact points between them. This can for example support seamless continuation between a subway map and a street map and reconcile different mapping approaches. Additionally, the vertical dimension can enable many other modes of interaction in complex urban spaces.

Conclusion

We presented some initial work on challenges occurring in complex overlapping structural spaces as they occur in modern large cities. An initial description of the issue was given along with some proposals towards possible solutions. Future work concerns different visualization approaches for 2D and 3D maps, ways to scale up to a city level, and different levels of granularity. We also need to better examine and understand the issue from a user side to see which navigation tasks could benefit most from the approach and which are the best interaction methods. Other open issues include questions of access and privacy if location data becomes even more accurate. We aim to develop this work further and tie it in with visualization approaches and granularity issues in geospatial data.

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