Purpose-Driven Navigation

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Abstract. Navigation in the context of GIS (Geographic Information Systems) is associated with a sequence of pan and zoom operations that lead to a specific destination. Navigation, in this context, leads a user to an *a priori* desired destination. There are cases, however, when users may not have a clear idea of a single destination. In this work, we propose richer navigational schemes by augmenting the concept of navigation to be broader than the goal of arriving at a single destination. This is achieved by identifying typical patterns of map use and the purposes behind such patterns, and defining corresponding navigational schemes. The proposed technique enables what we call *purpose-driven navigation* of maps, e.g., "scan region" or "explore neighborhood". We present example scenarios that demonstrate the benefit of purpose-driven navigation.

1 Introduction

It is widely acknowledged that moving data into the semantic domain greatly enhances the value as it enables richer and more natural queries than traditional keyword-based queries [1],[2]. The main disadvantage of traditional keyword queries is that the search results are dictated by the choice of keywords rather than the concept behind them. Similarly, the ability to define meaningful, purpose-driven interactive techniques with an information system can result in more compelling user experiences.

One of the key interactions with GIS is navigating in the virtual geographic environment. Navigation in GIS is usually defined as a point-to-point process. Such navigation is implemented as a sequence of pan and zoom operations that lead from start to destination location. This can be perceived as a fundamental form of navigation. However, not all interactions with geographic environments involve navigating from point to point. In some cases navigation may be motivated by goals other than just reaching a destination – for example, the purpose of navigation may be to explore a neighborhood to discover what prominent landmarks are present. Currently, support for such rich navigational schemes in existing GIS is absent. We address this gap in existing GIS by introducing the concept of parameterized, purpose-driven navigational schemes. This approach enables us to associate semantics with navigation.

The rest of the paper is organized as follows, the next section describes motivating scenarios that are not easy to solve with existing navigational support

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in GIS. We go on to discuss the issues that render the problems described difficult for the current systems. Our solution is then proposed in section 4 where purpose-driven navigational schemes are identified and parameterized. Section 5 gives details on how the proposed technique enables easy implementations of the scenarios described in section 2. We present conclusions in section 6.

2 Motivating Scenarios

In this section, we describe some scenarios that prompted us to develop a scheme for navigation based on intent. A GIS that includes road maps and satellite images of geographic regions is the focus of the scenarios presented. We present scenarios where people repeatedly create similar navigation patterns because of the purpose behind their interaction with a GIS.

- **Scenario 1:** Alice is considering relocating to a new neighborhood and would like to explore the region to know the locations of grocery stores, shopping malls, schools, etc. In this case, she would like a navigation scheme that automatically guides her through the neighborhood amenities in the context of her relocating to the neighborhood. She most probably will check more that one location to help her decide which location best suits her requirements.
- **Scenario 2:** Ben accompanies a friend to a location and later wants to find the address of where they had visited. All Ben can remember, however, is the appearance of the location (some trees and the kind of buildings in the region) and some general idea of where the location may have been geographically - like the southern region of Washington State. In this case he would like to be able to mark out a particular region on the map, that does not necessarily correspond to regions as defined in the data set, and scan this region till he finds the place that most resembles the place visited.
- **Scenario 3:** Charlie would like to view details in a wide region in the virtual geographic space and try to identify places of interest to him to tour when he visits the region. A brute-force scanning of the whole region is time consuming. Also, he may have certain regions that he knows he wants to visit.
- **Scenario 4:** Dana is planning a long drive and wants to choose some “interesting” roads to follow, she would like to know what is present on the road sides - is it scenic/mostly commercial/mountaineous, etc. She would like to view the road in the highest zoom level possible and follow roads, rather than directly “flying” to target destinations.

In all of these scenarios, navigation is complicated because there is no single start and destination location. The issues in the context of each scenario are described in the next section and possible solutions are outlined.

3 Issues and Solutions

User interaction with GIS is compelling if the navigation scheme is aware of the context of the navigation, and can automate the process of interaction using the knowledge of the user intent.

In the case of scenario 1, Alice has to find all the grocery stores in the neighborhood, in the current system she would have to enter possible names of stores and see if they exist in the neighborhood. In a semantic database, the task is simplified as all grocery stores can be identified by the labels associated with the data [4]. However, when Alice is exploring a neighborhood for relocating, she will have to make a list of all the amenities of interest to her, just to be able to query for them. This is cumbersome. The issue here is that in the current systems there is no way to point to a geographic region and indicate that our interest is to explore the neighborhood.

The solution is to define a purpose-driven navigational scheme that incorporates the concept of "explore neighborhood". This generic scheme is then parameterized to support the requirements of the user by associating with it a list of amenities to be explored in the neighborhood.

In the above scenario, associating the scheme of navigation with the user's intent enables identification of destinations. Once destinations are identified, existing point-to-point navigation with the additional information that the location specified by the user is the start point for all navigation provides the solution for "explore neighborhood".

The second scenario of Ben finding the place he had visited is more complex. The key issue is the inability to identify the destination of the navigation till one actually navigates through the relevant geo-spatial data. This is unsuitable for the existing concept of navigation that requires a well-defined destination.

The solution to the problem is to enable the Ben to select an area on the map and indicating that a scan of the region is to be performed. The system performs a zoomed-in scan of the region and the Ben can stop the scan when he recognizes the location.

In the third scenario, since the area to be toured is large, a scan-based solution will be cumbersome for Charlie. Also, he has additional information about locations in the area that he definitely wants to visit. The navigation process should therefore incorporate these points in the path it follows. One approach to implement a navigation for this scenario is to enable Charlie to mark his locations of interest as "perch locations". The navigation process then makes forays from these locations and enables identification of other locations of interest close-by.

In all of the above scenarios, there is no restriction on the path followed during the navigation. However, in scenario 4, Dana would like to follow roads; the typical navigation that flies or jumps directly to destination is not applicable here. We address this limitation in navigation by associating a property that enables a choice of type of path during navigation.

4 Generic Navigation Schemes

In this section we generalize the ideas presented in the previous section and describe generic navigation schemes; depending on the purpose of navigation we create a suitable parametrization of the navigation to enable user customization of the generic navigation scheme.

The concept of associating type with processes as opposed to only objects can explained in the context of the Object Process Methodology (OPM) [3] developed to enable challenging systems in which structure and behavior are intertwined. OPM is a holistic approach, to study and develop a system, which integrates the object-oriented and process-oriented approaches into a single frame of reference. We adopt this holistic view when defining generic navigation schemes.

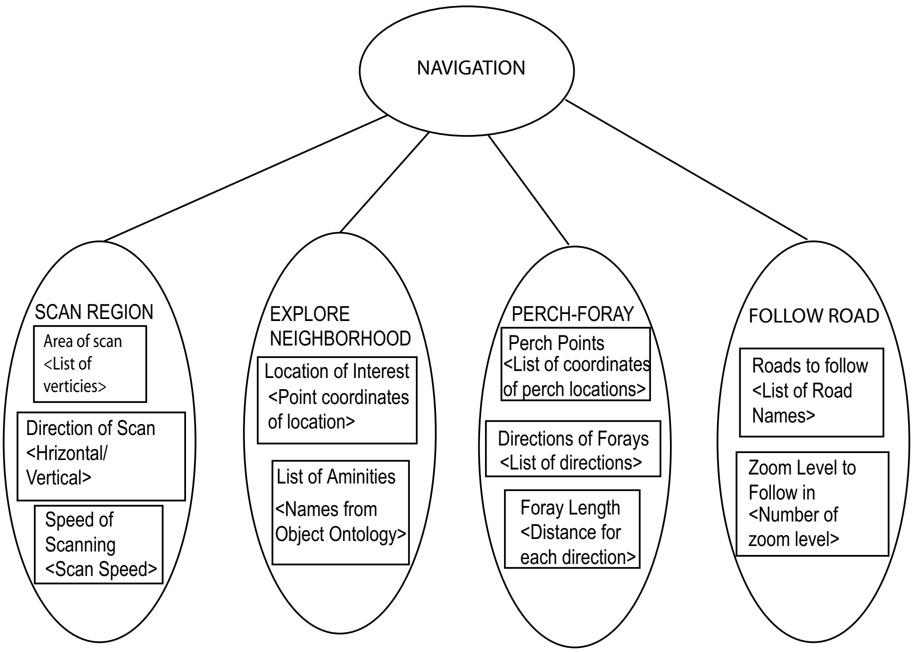

Fig. 1. Generic parameterized schemes for navigation "explore neighborhood", "scan region", "perch-foray" and "follow road"

Generic navigation schemes provide the user with a framework to incorporate additional knowledge in the system that automates navigation. The user no longer has to manually pan and zoom to find the required information in the GIS; the navigation system can be further tuned to the user interaction requirements using the additional parametric values defined by the user. Figure 1 outlines generic navigation schemes for "scan region", "explore neighborhood", "perch-foray" and "follow road".

Figure 1 also presents the parametrization of the generic navigational schemes. In "scan region" the list of vertices that define the polygon around the area of interest and the choice of direction and speed of scan are present. In "explore neighborhood" the point of interest around which to explore and the list of amenities that are of interest to the user are given. For "perch-foray" the list of perch locations, the directions of forays and length of forays for each direction constitute the information required to automate the navigation scheme. The list of roads and the level of zoom at which the navigation is to be performed is the parameters in the "follow road" scenario.

5 Example Information Flow During Navigation

In this section we describe the navigation process when it is associated with a generic scheme with parameters described in the previous section.

Figure 2 is an illustration of a GIS with generic navigational schemes is presented. We use ellipses to represent processes and rectangles to represent data. During interaction with the GIS a generic navigation scheme may be represented as the parameter values that the user provides to customize the navigation. Therefore it is represented as data associated with the process of navigation.

When users interacts with this GIS they select a mode of interaction that is either in the form of a text query or a navigation of the data. Users who choose to navigate are given the option of selecting either the manual pan/zoom approach or the richer navigational schema, namely "scan region", "explore neighborhood", "perch-foray" and "follow road". When one of these generic navigation schemes is selected, the user is prompted to give details to set parameters related to the particular scheme. For example, if "scan region" is chosen, they will be asked to provide the vertices of the polygon enclosing the scan region and also indicate the speed and direction in which they would like the area to be scanned, vertical, or horizontal. The navigation system then carries out the task of scanning and displaying the map to the user. Users interact similarly for other navigational schemes by providing the parameters to complete the data required for a particular generic navigation scheme. The system takes over once the parameters are defined and displays a suitable traversal through the geographical environment. (The precise UI for how users answer questions about parameters could be further refined.)

Figure 3 shows a highlight of an example path followed by the navigation system when it explores a neighborhood for places where food can be purchased.

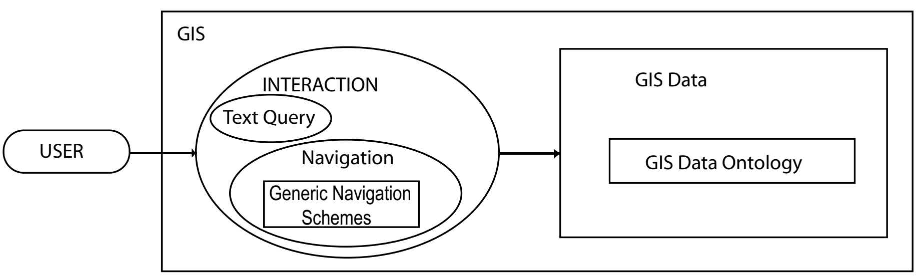

Fig. 2. Schematic representation of location of the generic parameterized navigation in GIS

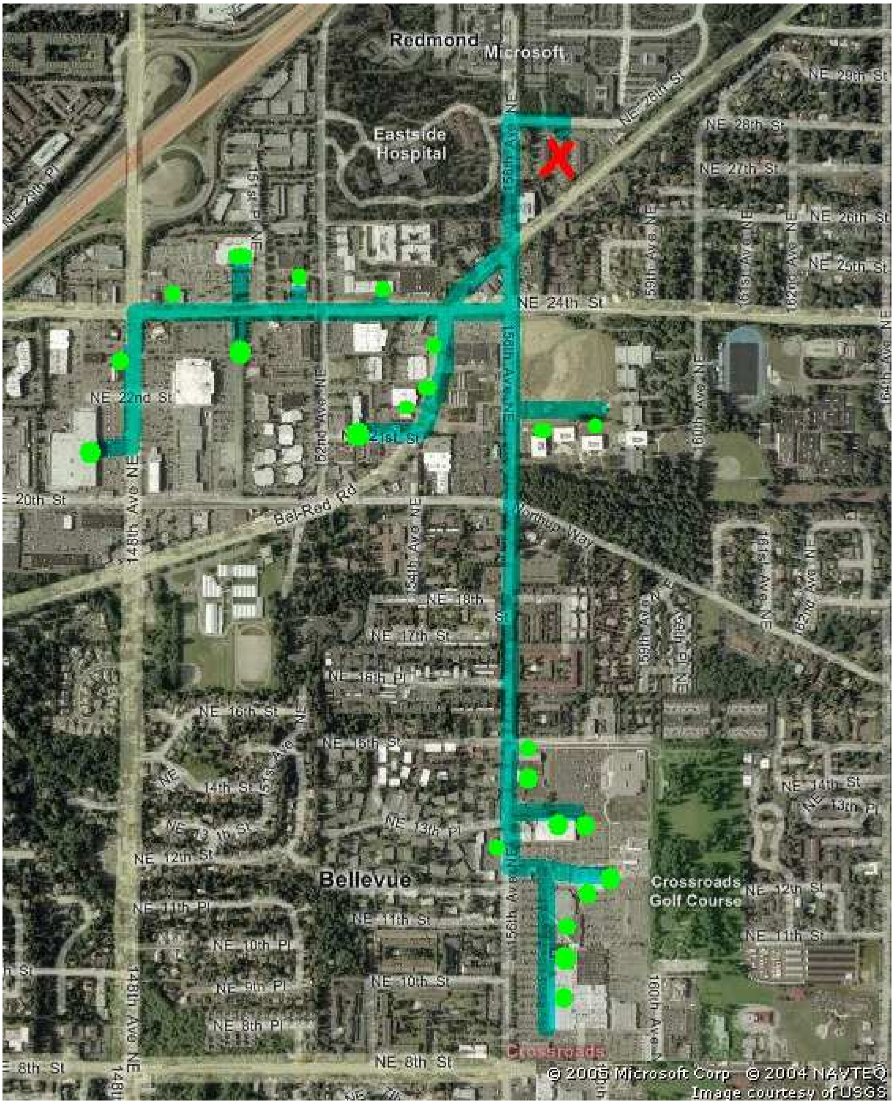

Fig. 3. Example navigation path, of the path traced by the system when the goal of the navigation is to explore all the places where food can be purchased (shown as green spots on the map) in the neighborhood of the location marked by a red x

We show a zoomed out version of the map with the path highlighted. In the actual system, the navigation tool will automatically follow the path highlighted on a zoomed-in version of the region and the user can see more details of the locations being visited by the automated navigation process.

6 Conclusions

We have presented a technique for creating complex navigation schemes in the context of GIS. Scenarios that warrant the use of purpose-driven navigation were described, and we develop suitable parameterized navigation schemes to support rich interaction. Knowledge of navigation purpose was used to automatically identify multiple destinations, and also a scan-based solution was proposed for the case when the navigation process itself leads to the identification of the destination. A "perch" and "foray" based generic navigation scheme was defined for the case of a tourist with partial information on locations of interest. A technique for enabling control of path of navigation was also proposed.

The development of generic navigational schemes described in this paper have general-purpose applications beyond the given scenarios. "Scan region", for example, can be applied in crime fighting where the law keepers may receive descriptions of locations, and navigation allows scanning of the region with reduced manual effort. "Perch-foray" can be used to gather information around a scattered set of locations in a wide region. "Follow road" can be applied by ecologists to follow the course of a river and examine various changes in environment along it. It should also be noted that we can combine these schemes like "follow road" with "explore neighborhood' to obtain richer information from GIS, like the distance in miles for a particular tour of the neighborhood, from which we can infer whether the gas in the car is sufficient to undertake a tour. Thus by defining purpose-driven navigation we are able to add compelling interactions with GIS beyond those of purely manual navigation.

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