Time Geography in Support of Mobile Activity Planning

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Summary: A prototype map-based mobile application is described that allows a user to plan spatio-temporal activities that consist of a sequence of actions. This application utilises an open source web based client-server architecture that can perform spatio-temporal analyses to ensure the planned activity adheres to the spatio-temporal constraints of the planner. The user is able to build these activities by making use of an interactive visual representation which allows the zooming of the map extents based on the potential path area of the user.

KEYWORDS: Time Geography, Mobile Information Seeking, Open Source, Geographic Relevance

1. Introduction

Activities of mobile individuals are constrained by the amount of spatial and temporal resources available to them (Miller, 2004). These constraints influence their decisions about where and when an activity can take place and therefore also which activities are possible. Developing systems that can enhance our awareness of these constraints can improve their usability by decreasing the number of cognitive operations necessary when making a decision (Crease and Reichenbacher, 2011). This is especially true of mobile information seekers who often have to take decisions that are based on the spatio-temporal constraints of their situation and the potential accessibility that these constraints allow. Research has already recognised this need and demonstrated conceptually (Raubal et al., 2004) and formally (Raubal and Panov, 2008) how these systems would work through the application of time geographical concepts. At the same time, recent research has also begun to recognise that assessing the relevance of geographic information has to be improved for mobile information seeking (Raper, 2007). To make these improved assessment methods usable, visual representations of relevance must also be developed that allow individuals to apply these improved relevance assessments to their everyday activities. This paper describes an implementation of a mobile mapping system that aims to support the information seeking of users planning spatio-temporal activities via map adaptation and novel interactive tools based on time geographical concepts.

2. Background

There has been recent interest in the conceptual extension of situational relevance in mobile contexts. This interest has been stimulated by the simple nature of existing relevance models that are not equipped to deal with the ever changing spatio-temporal contexts of a mobile information seeker (Reichenbacher et al., 2009). This new type of relevance has been termed Geographic Relevance and can be defined as a measure of the relatedness between an entity or its representation and the actual context of using the representation (Raper, 2007, Reichenbacher and De Sabbata, 2011). User studies have shown that spatio-temporal accessibility plays an important role in the assessment of Geographic Relevance (De Sabbata, 2010). This importance relates to the context of mobile information seekers, who often employ the information to support the planning of spatio-temporal activities. Such spatio-temporal activities have frequently been examined using the analytical framework of Time Geography (Hägerstrand, 1970). Research in this field seeks to understand and model constraints that space and time place on our ability to carry out these interactions in the external world. Locations of actors are conceptualised in Time Geography as being made up of a coordinate triple <x,y,t>, where x and y represent planimetric spatial dimensions and t time. Analysis of such data can provide measures of the observed spatial area accessible to an actor which can be used to further infer which activities are available to them (Kwan, 2000). Accessibility can be analysed through the calculation of space-time prisms representing the limits for all possible movements in space and time for a given time budget of an actor. One method to assess the potential future accessibility of an actor is to take temporal slices of these prisms and project them into 2D space, these slices are known as potential path areas (Kwan and Hong, 1998).

Currently research has addressed the information needs of individuals or groups of users for a single spatio-temporal activity which involves travelling to a location and carrying out an activity within a time budget (Espeter and Raubal, 2009). However, more complex spatio-temporal activities exist that consist of numerous sequential actions and goals that must occur within a time constraint (Seifert et al., 2007). Examples of these activities could be a day's sightseeing trip or a bar crawl. This form of activity is analogous to what time geographers refer to as a space-time project. Raubal et al. (2004) set out a theory of how these space-time projects could be built into location-based services with the addition of user preferences and affordances. The following sections describe a prototypical system that allows a mobile information seeker to become involved in the creation of these space-time projects.

3. Framework and Spatio-Temporal Analyses

Figure 1 illustrates the web-based architecture for a prototypical space-time planning application developed using open source tools. Geographic data is accessed from PostGIS via GeoServer and fed into a Java based analysis module employing the GeoTools library for basic data access and manipulation (Turton, 2008). A spatio-temporal accessibility toolkit (http://code.google.com/p/spatiotemporal-accessibility-toolkit/) based on the GeoTools and Sextante libraries (Olaya, 2008) was developed by the author and is responsible for calculating accessibility by dynamically computing shortest routes and potential path areas on street network datasets.

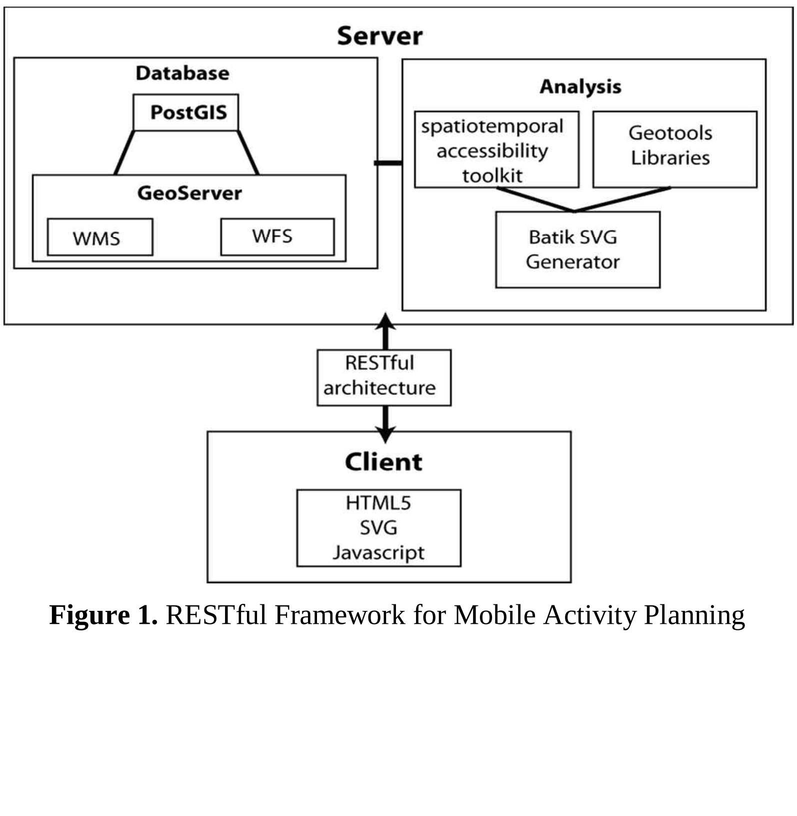

Figure 1. RESTful Framework for Mobile Activity Planning

The task of the analysis module is to adapt the client side map display by filtering the geographic information objects (GIO) that are no longer accessible within the current time budget and resize the map to fit the extents of the accessible area. This is an iterative process; first the user selects and chooses a GIO using the client side map interface. A request is then sent to the server and the time it would take to travel and perform the activity at this GIO is subtracted from the time budget. Accessibility is then re-calculated and a server response removes the inaccessible GIOs from the client side map. This process is repeated until no more GIOs are accessible. This is explained below in Figure 2.

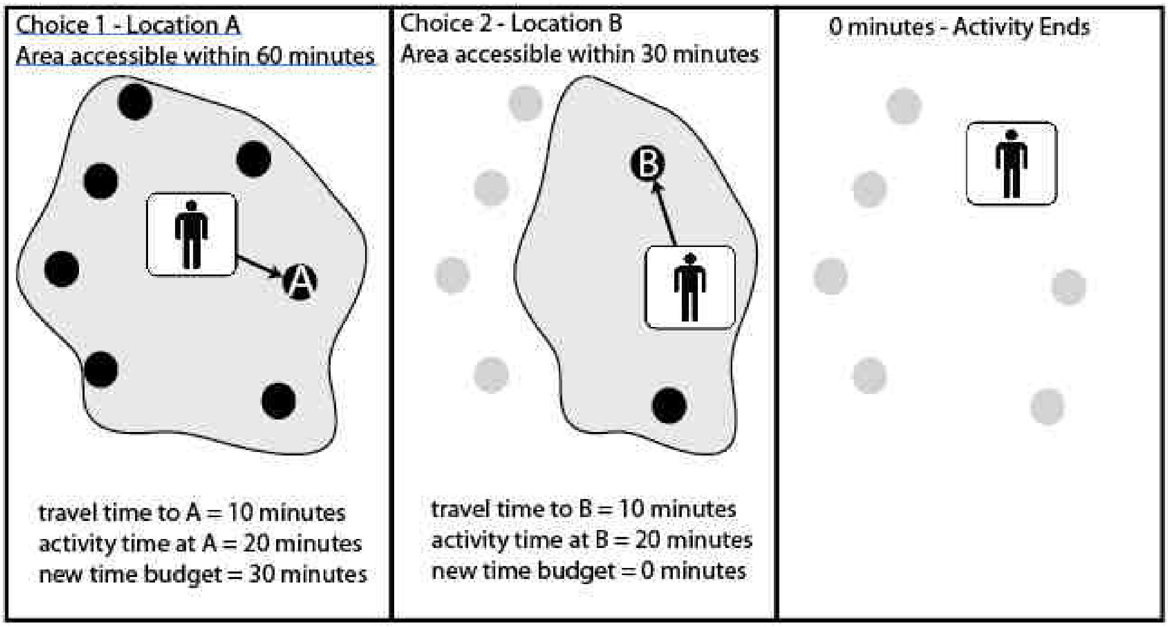

Figure 2. Schematic diagram showing the creation of a basic space-time project

The analyses that provide this functionality can be formalised in the following way. Travel time between two locations a and b is calculated using Equation 1:

$$travel(a,b) = \frac{d^{ab}}{v} \qquad (1)$$

Where d^{ab} is the total network distance when travelling from current location a to destination b and v is velocity of travel. The total activity time of travelling to a location and then carrying out the activity is then calculated with Equation 2:

$$actT(a,b,s) = travel(a,b) + {}^{s}duration \ (2)$$

Where s is total duration spent performing the activity at location b. As the locations for the activity are chosen the current time is calculated at which the activity would finish at the location last chosen. This is shown in Equation 3 below:

$$B = \{b_1 \dots b_n\} \qquad (3)$$

$$S=\{s_1 \dots s_n\} \qquad (4)$$

$$current(\mathrm{B}, \mathrm{S}) = start^{t} + actT\left(start^{xy}, \mathrm{b}_1, \mathrm{s}_{1,}\right) + \sum_{i=2}^{n} actT\,(\mathrm{b}_{\mathrm{i}-1}, \mathrm{b}_{\mathrm{i},}, \mathrm{s}_{\mathrm{i},}) \qquad (5)$$

Where Equations 3 and 4 are the ordered sets of activity locations and their associated durations, $start^{t}$ is the planned start time of the activity, $start^{xy}$ is the planned start location and n is the number of locations so far included within the space-time project. After these calculations Location k is only accessible if the following constraints hold in Equation 4:

$$\mathrm{current}(\mathrm{B}, \mathrm{S}) + actT(a, b, s) \leq start^{t} + \;p\mathrm{duration}\ \textbf{AND}\ k^{ot} \leq actT(a, b, s) \;\leq k^{ct}\ (6)$$

A well understood characteristic of space time activity is the degree of fixity of spatial and temporal constraints (Kwan, 2000). As some information seekers may be fixed on where to end the activity, accessibility can also be calculated with a fixed-end destination (Equation 7).

$$\mathrm{current}(\mathrm{B}, \mathrm{S}) + actT(a, b, s) + travel(b, c) \leq start^{t} + \;p\mathrm{duration}\ \textbf{AND}\ b^{ot} \leq actT(a, b, s) \;\leq b^{ct}\ (7)$$

Where c is the fixed-end destination, $p$duration is the planned duration for the space-time project, b^{ot} is the opening time of location b and b^{ct} is the closing time of location b.

4. Building the Space-Time Project

The client side features an HTML5 webpage that allows basic map interactions, such as scrolling, zooming, and selecting geographic information objects on an SVG image. Building a space-time project entails the following interactions: First the user must set the parameters defining the space-time project in a query form (Figure 3).

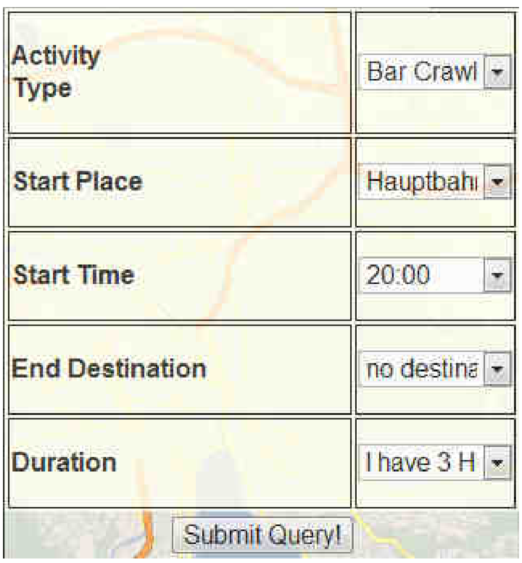

Figure 3. Query Form to plan a bar crawl for 3 Hours starting from the Main Station at 20:00

The decision on the activity type is followed by entering start and end locations. This choice is flexible so the information seeker is free to choose where the activity starts and ends. The user must also provide a start time and desired duration for the activity.

After having submitted the query a resulting maps shows the GIOs accessible within the specified time budget. As each choice reflects a movement in space, the spatio-temporal distances are important for a user to perceive. Therefore the potential path area for a time increment can be overlaid on the map and a zoom control allows the user to zoom in and out of the map by increasing or decreasing the time increment by one minute (Figure 4).

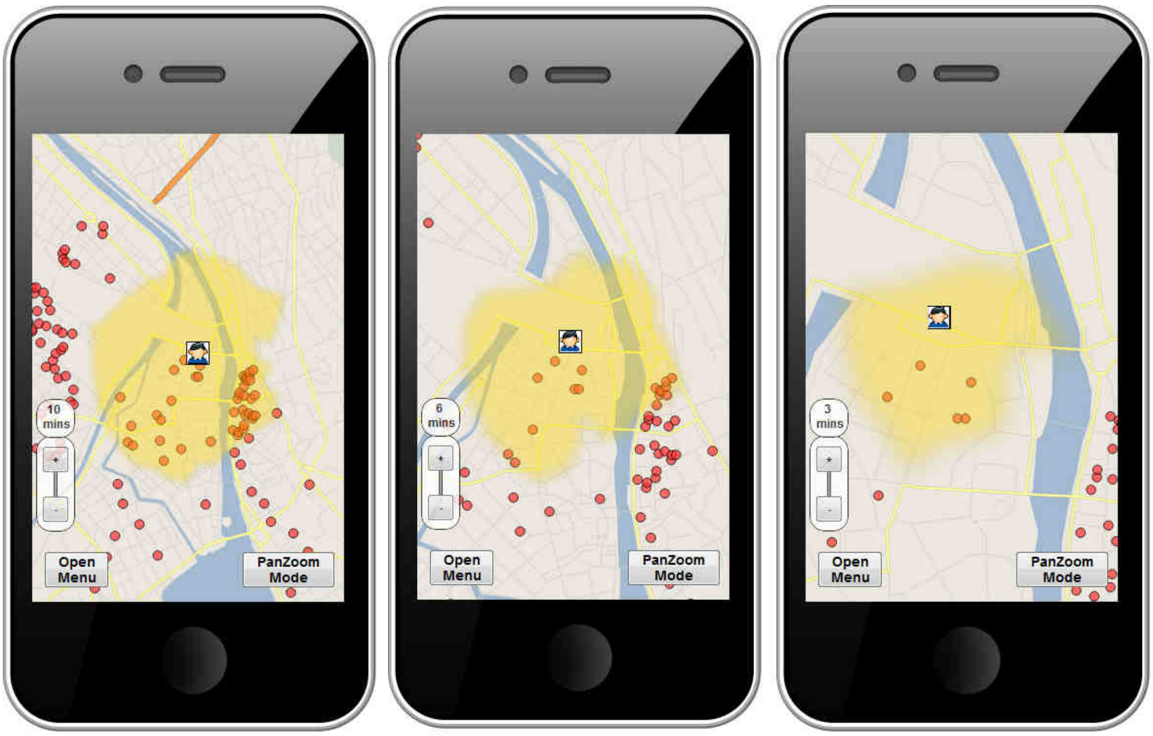

Figure 4. Potential path area zoom extents of a user walking for 10, 6 and 3 minutes at 5kmh

This link between map scale and potential path area enables the focus to rest on those GIOs of interest that meet the desired amount of travel time as well as avoiding the need to zoom and pan manually. Additionally, this may have cognitive benefits as the user's ability to estimate spatio-temporal distances will be enhanced. Once a GIO is selected, information about that GIO is displayed. Currently, the system gives the user the relevance rank of the object (calculated according to (De Sabbata and Reichenbacher, 2010)), price, review rating and a link to the website for that GIO. When the user decides to include a GIO within the space-time project the activity and travel time are subtracted from the time budget and a new filtered overview map is returned (Figure 5). This process carries on until no more GIOs are accessible within the time budget.

Figure 5. Interaction process - 1) overview map with user location and end destination (blue pin) 2) using the space-time zoom to find and select a GIO within a 9 minute walk 3) the time budget is recalculated, GIOs removed that are no longer accessible and the map automatically rescales to the accessible extent.

5. Summary & Outlook

This paper introduced an open source architecture that aids the planning of spatio-temporal activities. The implementation allows the user to build up a space-time project that adheres to the spatio-temporal constraints of the planner. Current real world mobile applications do not properly support the inclusion of spatio-temporal factors possibly hindering the decision making of mobile information seekers. Systems which are able to adapt to spatio-temporal constraints of an information seeker should better support not only the cognition of the user but also enhance the interactions required to seek relevant information. Future work will include extending the framework to support users currently engaged in an activity, who need to build these space-time projects on the go. This requires a different approach as simplified methods of interaction and more egocentric representations will be necessary to support the cognition of an actor as opposed to a planner.

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8. Biography

Paul Crease is a PhD student at the University of Zürich working on the GeoRel project. His research interests include Contextual Map Adaptation, Mobile Information Seeking, Spatio-Temporal Analysis and Cognitive Engineering.