Managing and Exploring Spatiotemporal Volunteered Geographic Information

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1. Introduction

As the sources of volunteered geographic information (VGI) continue to grow, we have access to a wide range of VGI created for different purposes and in various formats. Many issues and challenges related to VGI such as data authenticity, uncertainty, interoperability, integration, data mining, and knowledge generation have been identified. This paper will focus on managing and exploring spatiotemporal VGI with a space-time GIS design based on Hägerstrand's time geography.

2. A Space-Time GIS for VGI

It often is possible to retrieve spatial and temporal data from VGI. For example, we can retrieve the location and the posted date of each picture posted on Panoramio. Wikimapia allows users to retrieve the location of each polygon describing a map feature. We also can access the history of changes with posted date and username. On Blippy, we can retrieve the dollar amount, the store, and the date of each purchase made by individual contributors. OpenStreetMap permits us to download GPS tracking data with the posted date and username. It also is well known that spatial and temporal references in VGI often are far from perfect. For example, Blippy states that "Tammy spent $8.95 at Starbucks" without indicating which particular Starbucks store the purchase was made. In addition, most VGI sources only show when an item was posted in a format such as x days ago. This paper does not attempt to tackle data validity or uncertainty issues. Instead, This paper focuses on how we can use a space-time GIS framework to mange and explore spatiotemporal patterns hidden in VGI.

Hägerstrand's time geography examines human activities in a space-time context (Hägerstrand, 1970). Space and time are connected through the concept of *space-time path* that tracks an individual's sequence of activities at different locations over time (Figure 1). This 3D space-time framework works well with individual trajectory data. A prototype space-time GIS with spatiotemporal exploratory analysis functions have been developed by this author and his associates (Shaw and Yu, 2009; Yu and Shaw, 2008). There are three key elements associated with a space-time path. First of all, each space-time path has a unique identity tied to a particular person. The other two elements are spatial and temporal references. Every point on a space-time path refers to a specific location and time. We developed a temporal linear referencing system and a temporal dynamic segmentation method to integrate object identity with the spatial and temporal data of individual activities on a space-time path (Figure 2).

This space-time GIS can be extended for managing and exploring spatiotemporal data in VGI. Below are some examples based on object identity and spatial and temporal data embedded in VGI.

a) Fixed object identity with changing locations over time: GPS tracking data posted by contributors on web sites such as OpenStreetMap and MapMyRide belong to this category. History of editing changes made by each contributor on Wikimapia is another example. We can create a space-time path for each contributor based on the GPS tracking data or the change history data at their respective posted time.

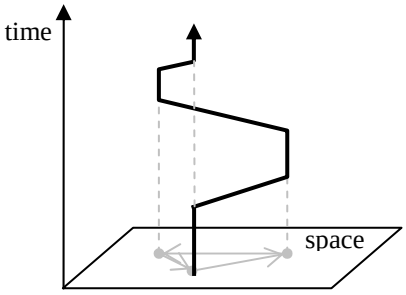

Figure 1. Space-time path.

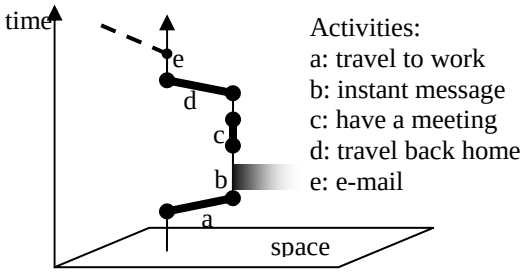

Figure 2. Temporal linear referencing and dynamic segmentation method.

b) Fixed object identity with ambiguous locations: For example, Blippy only lists store names where purchases were made. It usually is not feasible to identify the specific store location. For many applications, we only need to know the type of location rather than the exact location. Web surfing data is another example. It is sufficient for most applications to know which web site a person browsed rather than where a particular web site is physically located. Therefore, we can simply assign an arbitrary location to each store site or web site when creating a space-time path.
c) Fixed location with changing object identity: An example can be the changes made by different contributors to describe the same map feature on Wikimapia. In this case, a space-time path is created for each map feature at a fixed location. Changes posted by different contributors for each feature are mapped along the feature's space-time path. If contributors change the geometry describing a map feature, we can dynamically map the changing geometries to corresponding times along the feature's space-time path. In addition, we can link the changes associated with space-time paths created under item (a) and item (c) through unique key fields to explore spatiotemporal patterns by contributors or historical changes by particular map features.
d) Multiple locations of the same object identity: For example, people may post on Panoramio pictures of the same landmark (e.g., Washington Monument in DC) taken at different locations around the landmark. In this case, we can create multiple links between the space-time path of the landmark and space-time paths of people who took those pictures. This is similar to the implementation in Yu and Shaw (2008) for people who access multiple web sites at the same time.

3. Summary

VGI is available in various formats and for different purposes. This paper illustrates that we can develop a space-time GIS to manage VGI based on their object identity and spatial and temporal elements. This space-time GIS then can be used to analyze and explore spatiotemporal patterns and interactions hidden in various kinds of VGI.

References

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