Position Paper for 2013 CyberGIS All Hands Meeting
September 15-17, 2013

Developing a Space-Time GIS Data Model for CyberGIS

Ziliang Zhao and Shih-Lung Shaw
Department of Geography, University of Tennessee, Knoxville
zzhao7@utk.edu and sshaw@utk.edu

CyberGIS aims at facilitating extensive geospatial information sharing and delivering ubiquitous computational resources. Although many research breakthroughs in CyberGIS have been achieved over the years, additional efforts are needed such as the development of robust space-time GIS data models for CyberGIS. In this position paper, we highlight the needs, major challenges, and our thoughts of designing an innovative space-time GIS data model for CyberGIS.

GIS communities are increasingly dealing with and sharing spatiotemporal data that change in space and over time. In the meantime, GIS users continue to struggle with dynamically changing datasets due to the lack of a robust space-time GIS data model. This presents some critical challenges for CyberGIS communities to further facilitate information sharing and deliver computational resources. We believe that a robust space-time GIS data model will benefit not only data sharing but also problem solving and knowledge discovery in the CyberGIS era.

Some people might question that GIS researchers have proposed a number of space-time GIS data models over the past two decades and why we still need to develop an innovative space-time GIS data model for CyberGIS. First of all, most space-time GIS data models have been developed from the traditional space-dominant perspective. Time is considered as an "attachment" to space. Such a perspective could restrict the representation of different types of dynamics (e.g., time cycles, time branches) that are widely used in human societies. Second, many previous space-time GIS data models were designed to address specific problem domains and/or data types. As a result, compatibility issues may occur if multiple datasets organized by different data models are analyzed together. Therefore, there exists a need to design a space-time GIS data model for CyberGIS to facilitate data sharing and interoperation across GIS communities. Third, with the increasing data volumes available through volunteered geographic information (VGI) and sensor networks in the so-called Big Data era, researchers may benefit from using CyberGIS to deal with big datasets and solve complex scientific questions. This poses a demanding requirement on the scalability of space-time GIS data models. Since cyberinfrastructure already provides powerful capability of distributed computation, it will be beneficial for a space-time GIS data model to support big dynamic data by storing and analyzing them on multiple computers connected through the Internet.

To tackle the above challenges, a robust space-time GIS data model for CyberGIS should consider the following properties. First, space and time should be integrated more tightly,

rather than being treated as separate properties, in a space-time GIS data model. In other words, researchers should be able to access and analyze different datasets from spatial, temporal, or any combined spatiotemporal perspective. Second, we need to address some fundamental questions such as "what types of time should be included in the data model?", "how do we model dynamic geometries, attributes, and activities that can change in various ways?", "how do we support spatiotemporal processes beyond spatiotemporal snapshots in the space-time data model?", among others. Third, high performance geocomputation often employs the distributed-memory programming model to execute complex geoprocessing in parallel through cyberinfrasturcture. This approach requires a delicate and scalable space-time GIS data model that can partition an entire dataset from both spatial and temporal domains automatically and intelligently. In addition, the need of dealing with big spatiotemporal data in a CyberGIS environment also brings up concerns about load balancing and data security (e.g., what if one machine fails?) that must be addressed. Finally, on the physical implementation aspect, it may be better to design a space-time GIS data model based on the new database technologies (e.g., NoSQL) since they offer advantages over traditional database in terms of schemaless data structure, distributed data storage, and parallel analysis. We will discuss our approaches to these design considerations in more details at the 2013 CyberGIS All Hands Meeting.