Space, Time, and Human Activities in Virtual and Physical Spaces

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With advancements of information and communication technologies (ICT) such as the Internet and mobile phones, our world has become more connected, dynamic, and instantaneous than ever before. Human activity and interaction patterns therefore have changed accordingly. We now see a growing amount of activities and interactions taking place in virtual space. These virtual activities and interactions include, for example, *e*-shopping, *e*-business, *e*-government, *e*-news, *e*-entertainment, social networks, among others. Recent developments in location-aware technologies further have made it possible to collect real-time or near-real-time location tracking data. As a result, it now is feasible to monitor and track the dynamics of our world in a spatial and temporal context. Whenever an event occurs, we no longer need to wait for information released by news agencies or announcements made by government agencies. Much information is posted by individual persons or groups via ICT. This large amount of volunteered information (including volunteered geographic information, VGI) is available for public access that covers a wide range of topics related to our lives in this dynamic and mobile world.

Discovering and mapping the large amount of information available in cyberspace and linking it back to the activities in physical space present many research challenges. First of all, information landscapes are dynamic both spatially and temporally. For example, opinions about a particular event often vary spatially and evolve temporally. Information landscapes therefore are spatial and temporal processes that must be discovered in a space-and-time context. However, the conventional representations of space and time in geographic information systems (GIS) are inadequate for handling locations and time in virtual space. For example, how should we represent the locations of messages, photos and events posted by a person on his/her Facebook web page? Is it the location of Facebook's computer server, the location of the person at the time a message/photo/event was posted, the actual location associated with the message/photo/event, or a combination of the above? Also, should we use the posting time or the actual time associated with these message/photos/events to understand information landscapes? How do we keep track of the evolution of a particular theme (or person) or interactions among several themes (or persons) over time? Different approaches of representing and analyzing such information in virtual space are likely to lead to different information landscapes that could either enhance or mislead our understanding of a particular phenomenon. Therefore, it is important to address questions such as "what are locations in virtual space?" and "how do we represent locations and their associated time in virtual space?"

Another important research question is how the activities in virtual space interact with the activities in physical space. For example, the roles of Twitter and Facebook played in Arab Spring uprisings suggest the importance of discovering and mapping the interactions between virtual activities and physical activities. Mapping information landscapes in virtual space and activities in physical space separately cannot effectively reveal the spatial and temporal interactions between the virtual events and the physical events. In other words, we cannot treat virtual information landscapes and physical activity landscapes as two independent spaces and handle them separately. Otherwise, we would either discover partial reality at the best or reach a wrong conclusion at the

worst. Hägerstrand's time geography proposes a framework to examine human activities under various constraints in a space-time context (Hägerstrand, 1970; Shaw, 2012). 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. The *space-time prism* concept, on the other hand, delimits a feasible spatio-temporal opportunity space that an individual could conduct his/her activities under capability, authority, and coupling constraints. Although time-geographic concepts are developed mainly for human activities in physical space, these concepts can be extended to human activities and interactions in virtual space enabled by information and communication technologies. This time-geographic approach offers one possible framework of studying and discovering interactions between virtual space and physical space.

Furthermore, we need to develop an analytical environment that can adequately support data management, query, analysis, and visualization of information and activities in both virtual and physical spaces. This author and his collaborators have developed a space-time GIS based on an extended time-geographic framework for studying human activities and interactions in physical and virtual spaces (e.g., Yin, Shaw and Yu, 2011; Shaw and Yu, 2009; Yu and Shaw, 2008). For example, they use the concepts of physical space-time paths, virtual space-time paths, and social space-time paths to represent and analyze the physical movements, virtual interactions, and social relationships, respectively, in a space-time GIS environment. This multiple-representation approach in a space-time GIS illustrates one feasible way of representing, analyzing, and visualizing activities and interactions in a hybrid physical-virtual space. Spatio-temporal analysis methods also have been developed to identify spatio-temporal trends and patterns (Shaw, Yu and Bombom, 2008; Fang et al., 2012; Pei et al., 2013). In sum, there are many interesting and challenging research topics to be discussed at this workshop if our goal is to effectively discover and map various information landscapes in virtual and physical spaces.

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