High-resolution constraints on human actions and interactions in space and time

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A recent paper by Boman and Holm (2004) argues for the convergence of three approaches for modeling human spatial systems from the "bottom-up": i) microsimulation; ii) agent-based modeling (ABM), and; iii) time geography. These approaches offer complementary strengths for analyzing and understanding human phenomena. Microsimulation offers a tradition of computational approaches to understanding how micro-level behavior creates dynamic human phenomena, as well as standards for model estimation and validation. However, microsimulation models typically represent human behavior in an aggregate and isolated manner since behaviors manifest from cohorts rather than individual actions, interactions among humans, as well as interactions between humans and the environment. In time geography, interactions among humans and with the environment are fundamental, but linkages between individual behaviors and aggregate social and environmental dynamics are only conceptual in nature. ABM offers a rigorous but rich approach to simulating human phenomena from the bottom-up, as well as the concepts of adaptation, self-organization and emergence to capture linkages between individual behavior and aggregate dynamics. ABM can benefit from time geography's focus on constraints, as well as microsimulation's adherence to estimation and validation standards.

While time geography has much offer as a conceptual foundation for ABM, a weakness is its traditional lack of a rigorous analytical foundation. Time geographic entities such as the path and prism, and relationships such as path bundling, path-prism intersections and prism-prism intersections, are described only informally. Classical time geography is not sufficiently developed to support measurement and analysis using high resolution technologies such as ABM, as well as data collection using *location-aware technologies* such as the global positioning systems (GPS) or radiofrequency identification (RFID) chips.

Rigorous, high resolution constraints on human activities and interactions in space and time are possible through temporal disaggregation of time geography. At a given moment in time, entities such as the space-time path and prism are simple geometric objects in the low-dimensional space of interest in time geography. For example, the space-time path at a given moment in time is a point object. Further, the space-time prism at a given moment in time is the intersection of three compact spatial sets that have simple geometric forms. Given the low dimensional space of interest in time geography, it is easy to solve for the prism, prism-prism and path-prism intersections, as well as other relationships such as path bundling (Miller 2005a). In addition to allowing easy solutions, the temporal disaggregation meshes well with the discrete temporal dynamics in microsimulation, ABM and LATs.

The high-resolution time geographic measurement theory can also be extended to encompass virtual interaction. Using Janelle's typology of interaction constraints based on spatial presence versus telepresence and temporal synchronicity versus asynchronicity as a foundation (Janelle 2004), we introduce new time geographic objects: i) a *portal* (locations that allow virtual interaction), and ii) *message windows* (potential or actual communication events represented as time intervals). Using the well-known Allen time predicates that encompass all possible relationships between two intervals of time, it is possible to derive the rigorous constraints on communication events within the Janelle framework (Miller 2005b).

More recently, we have extended the time geographic measurement theory to the case where travel velocities vary continuously across space. Using the continuous transportation modeling or "urban fields" theoretical tradition in geography and regional science, we formulate analytical definitions of the space-time path and prism for the case where unobserved components are characterized by minimum cost curves through an inverse velocity field rather than straight line segments based on a uniform velocity. The theory is more realistic and also links time geography to the continuous space modeling tradition in geography and regional science. In addition to theoretical relevance and elegance, the time geographic field approach provides a synoptic summary and visualization technique that can provide insights to space-time accessibility patterns. Preliminary results suggest that the space-time prism is sensitive to the velocity assumption, and the traditional prism based on a uniform maximum velocity assumption is only a special case of a family of prisms with a wide range of geometric forms.

Literature cited

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