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Somayeh Dodge serves as Assistant Professor of Spatial Data Science in the Department of Geography at the University of California, Santa Barbara. She received her PhD in Geography with a specialization in Geographic Information Science (GIScience) from the University of Zurich, Switzerland in October 2011. She holds a MS degree in GIS Engineering and a BS degree in Geomatics Engineering from the KNT University of Technology, Iran. Dodge's research focuses on developing data analytics, knowledge discovery, modeling, and visualization techniques to study movement. Her research applies spatial data science and computational approaches to advance the knowledge and understanding of how movement patterns are formed in dynamic natural and human systems. She has published in a number of high-ranked international journals such as *Methods in Ecology and Evolution*, *International Journal of Geographic Information Science*, *Philosophical Transactions of the Royal Society B*, *Journal of Spatial Information Science*, *Movement Ecology*, *Computers, Environment and Urban Systems (CEUS)*, *Geographical Analysis*, and *Information Visualization*. Dodge has recently been appointed as the Editor in Chief of the *Journal of Spatial Information Science*. She currently serves on the editorial board of multiple journals including *Geographical Analysis*, *CEUS*, and *The Professional Geographer*.

Before joining the UC Santa Barbara faculty in July 2019, Dodge worked as Assistant Professor at the University of Minnesota, Twin Cities (2016–2019) and University of Colorado, Colorado Springs (2013–2016). Prior to that, she completed a postdoctoral research at the Department of Civil, Environmental, and Geodetic Engineering (The Ohio State University) to develop Movebank EnvDATA (Environmental-Data Automated Track Annotation) System[1] which has been featured as a milestone in movement ecology.

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Towards Movement Data Science

Ubiquitous collection of geo-enriched tracking data necessitates new approaches for the analysis and sense-making of large and multidimensional arrays of information about movement of individuals, goods, vehicles and other mobile agents in space and time. In this position paper, I recommend a data science paradigm for movement research. The premise is that data science can advance interdisciplinary research on movement in various applications (e.g., human mobility, public health, movement ecology) through high-performance computing, intelligent algorithms and machine learning approaches. This is especially important when movement data are multidimensional (i.e.,

[1] https://www.movebank.org/node/6607

include space-time-context information) and represent long-term movement patterns of a large number of mobile entities in relation to their geographic and environmental contexts. The proposed data science framework, presented in Figure 1, was recently published in Dodge (2019). The readers are referred to the paper for details. Here, I briefly describe the framework and highlight the promises of data science and its new opportunities towards "an integrated science of movement" (Miller et al., 2019) for advancing societal and ecological applications.

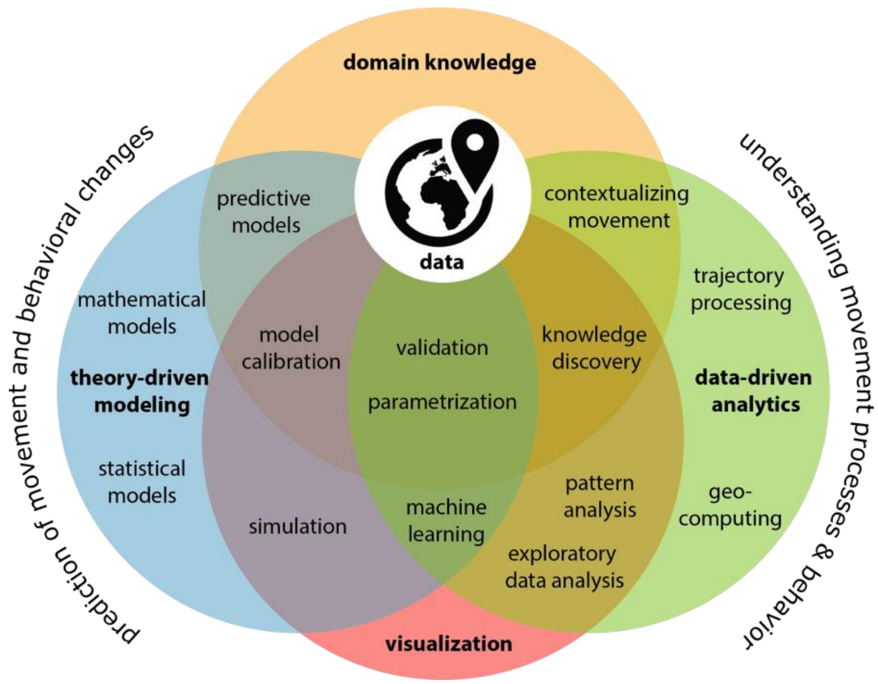

Figure 1: The data science framework for movement (from Dodge, 2019)

The framework blends raw **data** (i.e., movement and contextual observations) with **domain knowledge**, through **data-driven analytics** and **theory-driven modeling** to discover new insights about the behavior of moving individuals and advance our prediction of changes in dynamic systems. It uses an interdisciplinary approach supported by information **visualization** and geocomputing techniques to unravel hidden patterns and interactions in complex trajectory data sets. The framework enables research on movement through an iterative process, in which raw movement data are transformed to meaningful information about the behavior of tracked individuals through data-driven knowledge discovery approaches. This knowledge is then used to inform modeling and prediction of movement with the aid of theories, and mathematical and physical principles. This process is reliant on tracking data sets (i.e., time-ordered sequence of GPS observations, social media posts, check-ins, activity signals, etc.), computing, math, statistics, visualization, spatial knowledge, and domain knowledge.

Promises and Open Opportunities

With the rise of "big data" (Cukier and Mayer-Schoenberger, 2013), the Geographic Information Science (GIScience) community has been a key player in advancing methodologies for the collection, processing, analysis, visualization, and sense-making of large space-time data sets. While GIScience has significantly advanced computational movement research (Long et al., 2018), with the emergence of new forms of heterogeneous and multifaceted tracking data, new interdisciplinary approaches are needed to revolutionize the way we analyze and model movement. Access to massive amounts of fine-resolution tracking data that are geo-enriched with behavioral and contextual information provides new opportunities for multi-scale modeling of movement through integrating a range of patterns from locomotions to global patterns of movement. This also leads to an increasing demand for more efficient data fusion techniques to integrate diverse data sets obtained from different types of sensors and collected in multiple forms and granularity. Larger sample size of tracked individuals opens new opportunities for research on collective behavior of dynamic systems, and hence amplifies the need for approaches to model movement interaction and map the contribution of individual level patterns to the larger population level dynamics. Recent progress in movement research highlights the promising potential of deep-learning, artificial intelligence, machine learning, and information visualization techniques for leveraging massive and multidimensional movement data sets in understanding human dynamics and ecological systems. As mobile data collection has become pervasive and since tracking data can be easily linked to personal information, movement research should leverage advanced statistical and data science approaches to account for privacy of tracked individuals, as well as uncertainty, bias, and error in observations especially when dealing with volunteered geographic information.

References

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