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Spatial Data Science beyond Absolute Space

Spatial data science "is concerned with the representation, modeling, and simulation of spatial processes, as well as with the publication, retrieval, reuse, integration, and analysis of spatial data" (http://spatial.ucsb.edu/2019/spatial-data-science-symposium). Although spatial data science has been successfully applied in a wide range of disciplines, most spatial data science applications are built on the concept of Newtonian absolute space, which assumes an immovable empty space that can be filled with various objects. This absolute space approach is useful to represent, analyze, and visualize many spatial phenomena in physical space; however, it is insufficient for human dynamics research especially in the modern world. Recent technological advances have introduced many important changes to how people carry out their activities and interactions and how modern urban, economic, social, and political systems operate in an increasingly hybrid physical-virtual space that can no longer be handled properly by conventional spatial data science based on the concept of absolute space with Euclidean geometry and Cartesian coordinates.

Let's consider how *humans* have been represented and processed in conventional spatial data science. For example, conventional geographic information systems (GIS) often treat humans as an aggregate number associated with a polygon or a grid cell, points on a map, or paths reflecting their

trajectories over time. Spatial data science rarely considers humans as autonomous, intelligent entities that possess not only locations and attributes but also behaviors, perceptions, feelings, and thoughts related to spaces and places. Egenhofer and Mark (1995) suggest that naïve geography "captures and reflects the way people think and reason about geographic space and time" (p. 4). They further argue that future GIS can be built from the formal models of common-sense geographic world, which can be used by average citizen in dayto-day tasks without receiving major training. In fact, they suggest that "Naïve geography is also the basis for the design of intelligent GISs that will act and respond as a person would" (Egenhofer and Mark, 1995, p. 2). To what extent can the conceptualization of space and various models and methods in spatial data science today properly capture and reflect the way people think and reason about geographic space and time? This paper argues that we need to consider spatial data science beyond the concept of absolute space and bring it closer to the way ordinary people think and reason about space.

Spatial data science based on the concept of absolute space is ill-equipped to capture human dynamics that the physical and virtual, objective and subjective, territorial and topological worlds are increasingly coupled and entangled for most human activities from local to global scales. Shaw and Sui (2018) propose a multi-space GIScience framework for human dynamics research (see the red-color content in Figure 1). They argue that the current practices are conceptually constrained due to their confinement to absolute space and physical place. Shaw and Sui (2019) recently extend their multi-space framework to a more inclusive space-place (splatial) framework (Figure 1) in which they aim to encompass multiple dimensions of both space and place and a better way of understanding human dynamics through a synergistic perspective of both space and place.

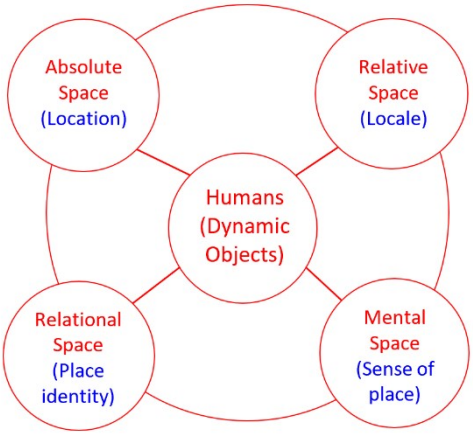

Figure 1. A space-place (splatial) GIScience framework for human dynamics research.

Absolute space in the splatial framework is similar to Newton's concept of absolute space that is infinite and immovable and can exist independent of anything external. Newton, on the other hand, considers relative space as some movable dimension or measure of the absolute space. *Relative space* in the splatial framework is consistent with this definition and allows the origin of a Cartesian coordinate system to move with a moving object (e.g., an autonomous vehicle that can constantly detect the relative locations of objects in its surrounding environment). *Relational space* in the splatial framework focuses on how things are related to each other. The location of each object in a relational space is measured by its topological relationships to other objects. Social network graphs are good examples of relational space since these graphs can be continuously transformed to other shapes as long as their topological relationships are maintained. *Mental space* in the splatial

framework is connected to the Kantian notion of space, which views the nature of space as a question about the nature of the observer who can have his/her own perceived space of things and events in the world. For example, a neighborhood could be perceived by some people as safe while other people might perceive it as unsafe. Spatial data scientists who extract semantics from various types of geospatial datasets are examples of going beyond absolute, relative, and relational space and moving into mental space to gain deeper insights of human behavior and human perception. Story maps, which tell a story with not only maps but also narrative texts, photos, videos, sounds, etc., also indicate the limitations of conventional approaches and a need to express the feelings and perceptions of a storyteller that cannot be accomplished by the concepts of absolute, relative, and relational spaces alone. *Humans*, which are dynamic objects themselves, are at the center of the splatial framework to replace locations as the central focus in conventional spatial data science. The circle that connects all four spaces in Figure 1 indicates that transformations or linkages can be performed among these four spaces such that they become an integrated, organic whole instead of four separate, independent spaces.

In addition, this splatial framework associates each of the four conceptualizations of space with a specific concept of place. First, absolute space is associated with the concept of *location*, which suggests a specific position or site that can be conveniently represented by coordinates in absolute space. *Locale*, which focuses on the situation rather than the site of an object, fits well with the concept of relative space. In relational space our focus shifts to *place identity* instead of location or locale since relational space is based on topological relations rather than specific locations. Mental space, on the other hand, is associated with *sense of place*, which attempts to reflect what people have in mind about a location, a locale, or a place identity that are associated with absolute space, relative space, and relational space, respectively.

It is important to note that humans do not limit their views of space to absolute space or place as a location. By transcending the absolute conceptualization of space, the splatial framework can expand and enrich our conceptualization of space and place, thus making spatial data science more powerful and useful to human dynamics research as well as research in the humanities and social sciences. I look forward to having discussions and brainstorming ideas with other researchers at this Spatial Data Science Symposium.

References:

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