[FC-02-003] Philosophical Perspectives

Abstract

This entry follows in the footsteps of Anselin's famous 1989 NCGIA working paper entitled "What is special about spatial?" (a report that is very timely again in an age when non-spatial data scientists are ignorant of the special characteristics of spatial data), where he outlines three unrelated but fundamental characteristics of spatial data. In a similar vein, I am going to discuss some philosophical perspectives that are internally unrelated to each other and could warrant individual entries in this Body of Knowledge. The first one is the notions of space and time and how they have evolved in philosophical discourse over the past three millennia. Related to these are aspects of absolute versus relative conceptions of these two fundamental constructs. The second is a brief introduction to key philosophical approaches and how they impact geospatial science and technology use today. The third is a discussion of which of the promises of the Quantitative Revolution in Geography and neighboring disciplines have been fulfilled by GIScience (and what is still missing). The fourth and final one is an introduction to the role that GIScience may play in what has recently been formalized as theory-guided data science.

Keywords: metaphysics, ontology, Philosophical foundations, philosophy, space, time

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Explanation

1. Definitions (from Beguin & Thiesse 1979)

Definition 1: A place s is an elementary spatial unit.

Definition 2: Space S is a set of (at least two) places. Space is interpreted as the stratum of natural and human processes.

Definition 3: Places are separated and this separation can be characterized by their relative position. The distance dL between any two places is a length metric. The metric can be n-dimensional if there are at least n+1 places - in which case μA is a measure of extension.

Corollary 1: A restricted definition of space is given by the triplet (S, dL, μA).

Definition 4: Simple attributes μ_i are described by a mass available over any measurable subset of places in S. Composite attributes are then defined as functions of simple attributes and/or of basic components of space S.

Corollary 2: An extended definition of space incorporates simple attributes [S, dL, μ_A, $(\mu_i; i \in \mathrm{I})$].

Definition 5: A moment t is an elementary temporal unit.

Definition 6: Time T is a set of (at least two) moments. Time is the temporal medium for natural and human processes.

Definition 7: Moments follow one another in a one-way course forming a totally ordered set. As such time resembles the set of integers.

Definition 8: Subsets of moments have a temporal extension, also known as duration. Analog to its spatial equivalent in definition 3 and corollary 1 it is defined as the non-negative measure μ_D.

Corollary 3: A restricted definition of time is given by the triplet $(T, \leq, \mu_D)$.

Definition 9: Simple attributes mi are described by a mass available over any measurable subset of moments in T. Composite attributes are then defined as functions of simple attributes and/or of basic components of time T.

Corollary 4: An extended definition of time incorporates simple attributes $[T, \leq, \mu_D\, (\mu_i; i \in \mathrm{I})]$.

2. A Space and Time

Space and time are two of the first abstract notions that humans learn in their childhood (Stea & Blaut 1973). They are so basic that we don't pay much attention to them and have difficulties to think consciously about them. This section will deal with the attempts of philosophers to get a grip on these concepts. What most lay people and experts agree on is that spatial and temporal properties are of a different kind than the substantive properties that describe objects and events. Beyond these, we are dealing with dichotomies: space and time can be conceptualized as absolute (exiting independent of objects and events) or as relative (coming into existence only as a relation among objects and events). And space and time can be conceptualized as either being something real (physical) or as something that exists only in our minds. Whenever we try to deal with space in formal terms, we resort geometry, which again can be interpreted as an actual description of physical space or a purely mental abstraction. Philosophical musings about these are somewhat in line with science advances and can therefore be grouped into classical (mainly influenced by ancient Greek, hence the topic's image of the School of Athens), the period of Enlightenment, and modern (20th century).

Classic conceptualizations established all the principles that form our everyday understanding of space and time. The one exception is the role of numerical theories, which according to Plato reflect the true nature of things (the episteme) rather than the inferior nature of empirics, which is limited by human capacity to understand things. The earliest theories are attributed to Heraclitus who observed the intricate link between space and time and declared everything to be process. For processes to occur, there must be empty space (the void) that allows things to move and change. Democritus explained qualitative change with the constant movement and re-configuration of atoms. Everything could be broken down into parts and counted, even space and time. Plato's counter-argument that circular movements allow for a void-less world spawned the transition from simple arithmetic (which does not allow for irrational numbers) to Euclid's geometric theory, which synchronized empirical and abstract conceptualizations and remained uncontested until the end of the 19th century. However, it was Aristotle's definition of place that defined space as an absolute container, where each thing finds its place relative to other things.

This dichotomy, space as an absolute container but all measurements being relative to the things they are applied to is also reflected in Newtonian dynamics, which was Enlightenment's modernization (but not repudiation) of Aristotle's and Euclid's theories. There were idealists like Locke and Berkeley, and most importantly Leibniz, who refuted absolute notions and saw space as a system of relations. Leibniz' ideas, although never published a single authoritative piece of work, form the strongest argument for a relativist perspective, foreshadowing post-Newtonian physics but also forming the philosophical basis for GIS data structures like the Voronoi diagram or Simplicial Complex (Jiang & Omer 2007), yet the sheer value of applicability of Newton's methods to science and subsequent industrialization put idealist approaches on a backfoot (see also section 4 on relevant philosophical schools of thought). Newton's relatively weak arguments for absolute conceptualizations (which was contradicted by his own work on dynamics) was upheld by the most influential philosopher of his time, Kant. For Kant, space and time are not aspects of the physical world (and can hence not be contradicted by lower-level theories) but are mental constructs – very much like Plato's ideals. He called his philosophy transcendental idealism, which makes sense at a superficial level but at the same time the term is confusing because his conclusions were the opposite of Leibniz'. For Kant, there is an unsurmountable distinction between mutable things on one side and the absolute characteristics of space and time on the other that defined the ontological basis of much of science and philosophy for the next hundred years.

Modern conceptualizations of space and time are influenced by three significant scientific insights that changed world views held since antiquity and that are so different from the experiential world of everyday citizens that they still are not typically taught outside of college. The first of these was the development of field theory, which got rid of the notion that space outside of things is empty. Maxwell's fields are filled with energy of varying degrees of magnitude and thereby give space a material entity. He broadened physics beyond Newton's mechanical perspective and allowed energy and matter to be two sides of the same coin. This was a necessary step towards Einstein's space-time manifold, where the two not only influence each other but are also bent by matter/energy. Kant's neat separation between material and mental dimensions were thus thrown out. Most of these modern theories can only be formalized by new mathematics that breaks the bounds of Euclidean geometry and the conceptualization of a range of mathematical spaces (Riemann, Poincare, Minkowski, Hilbert). Where both field and relativity theory assume dimensional continuity, its yet incompatible twin quantum theory posits matter or energy to be discrete. We will revisit this ontological conundrum when we look at the role of GIScience in the age of data science.

3. Relevant Philosophical Schools of Thought

Section A had a sincerely metaphysical touch and disregarded other fields of philosophy such as epistemology, logic, the philosophies of language or science, or political and environmental philosophy. We have separate BoK entries on epistemology and ontology, and deal with logical and ethical aspects of GIScience in other sections such as GIS&T and Society. But there are several aspects of metaphysics that a student of GIS&T will encounter on a regularly basis and that therefore require elucidation. Although we have spent some time on metaphysical questions of space and time, we have not defined metaphysics itself. Metaphysics is about the fundamental nature of reality, including the relationship between mind and matter and substance and attribute. Science used to be an integral part of metaphysics and separated only when the scientific methods, i.e., the empirical activity based on experiments became its own rationale, detached from larger metaphysical questions. We saw this tight link in section A until about the advent of field theory and newer forms of mathematics.

If the scientific method is about gathering empirical evidence, then it might come as a surprise that Empiricism is not a branch of metaphysics but of epistemology. Empiricism, not as a method but as a school of thought is based on the premise that knowledge can come only from sensory experience. This contrasts with the notions of Rationalism or Idealism, where knowledge may be derived by other means such as intuition or reasoning. Taken literally or narrowly, Empiricism does not allow for experiences to be transmitted in form of teachings or tradition. As this is a rather impractical notion, it is here only of interest as the counter view to rationalism. Rationalism is based on the process of reasoning and assume that certain “rational” principles such as logic, ethics and metaphysics are so fundamentally true that the attempt of attaining knowledge without these would be futile. Examples for such forms of reasoning range from Socrates to Descartes and Habermas. Especially during the age of Enlightenment, rationalism was the unifying force behind the divergent philosophies of Kant, Spinoza, or Leibniz. Positivism then combines these two strands. It holds the empirical method in high regard but allows for the deductive method of rationalism, while adding one additional constraint: Positivism requires the continuing verification of facts that then results in certitude or truth; it is an epistemology that states that there is no innate knowledge (as idealists would claim) and that truth can only be found a posteriori.

This conflict between idealism and positivism lies at the basis of the early 20th century school of phenomenology, where our experience is directed toward things only through particular concepts, thoughts, ideas, images, etc. These make up the meaning or content of a given experience and are distinct from the things they present or mean. Following Smith (2018), phenomenology develops a complex account of spatial and temporal awareness, attention, awareness of one’s own experience as well as self-awareness, the self in different roles (as thinking, acting, etc.), embodied action (including kinesthetic awareness of one’s movement), purpose or intention in action (more or less explicit), awareness of other persons (in empathy, intersubjectivity, collectivity), linguistic activity (involving meaning, communication, understanding others), social interaction (including collective action), and everyday activity in our surrounding life-world (in a particular culture).

Although closer to notions of behavioralism in the social sciences, phenomenology influenced many modern strands of philosophy ((post-)structuralism, feminism, critical theory) in its rejection of universal truths. It experiences a resurgence in the 21st century as part of the discussion of the role of technology (in particular artificial intelligence) and the way it alters our ability to reason about fundamental concepts (π Research Network 2019) – see also section 5.

The other big new branch in philosophy, starting in the late 19th century, is based on the works of Hegel and Marx. The latter rejected both idealism and any form of positivism that is divorced from political practice, encapsulated in “the philosophers have only interpreted the world, in various ways; the point is to change it” (Marx 1886, p 15).

4. Unfulfilled Promises of GIScience

Aristotle divided theoretical philosophy into natural philosophy, mathematics, and metaphysics (Copleston 1946). While natural philosophy is nowadays often equated with physics, Aristotle afforded a significant amount of his works to the description of phenomena that we would associate with the discipline of geography, be is as a spatial science (including astronomy and surveying) or as the backcloth of describing and explaining differences in biology, geology, and anthropology. We won’t concern ourselves here with the history of geography and how its various branches became proper scientific disciplines by themselves, now with generic systematizations of geographic knowledge. One methodological development though had significant influence on what is now known as GIScience: the quantitative revolution in geography in the 1950s and ‘60s.

The quintessential summary of the status of “Geography as a fundamental research discipline” was Ackerman’s 1958 University of Chicago research paper, which is unfortunately really hard to find. Ackerman identified the traditional approaches of underlying the geo-relational principle, regionalization, process-orientation, and identification of co-variances as the toolset common to most geographers of his days. But then he listed five challenges of “modern” geography, of which one could argue only one has been adequately addressed by GIScience methods (page 35):

1. Study of the nature of distributions
2. Perfecting observational techniques
3. Study of the effects of processes on distributions
4. Study of covariances of processes
5. Integration of processes in a region

The first of these is easily identifiable as a call for spatial analysis methods. We have made good progress on these. Back in the 1950, geographers still suffered from a dearth of data. This is where we have arguably achieved most progress; although this topic will have to be revised in section 5. The remainder of this list is all process-oriented and the importance of this 1958 research agenda cannot be over-stated. (#3, Study of the effects of processes on distributions) is an acknowledgement of the nature of change (see also the introduction to section 2). (#1, Study of the nature of distributions) is important but useless if we do not study the effect of the context setting of the structure of distributions as well as their changing nature. This requires considerably more than what we capture in GIS. Geo-spatial ontologies, scale-dependent analyses, and the general identification of what is important in a particular topical or chorological context would be first steps to fulfilling this item on

Ackerman's research agenda but at this point, we are thoroughly deficient in deploying the kind of knowledge representation that is necessary to check off this item.

(#4, Study of covariance of processes) deals with the fact that processes interact with each other and across scales. Ackerman does not use the term system science, but this is exactly what he describes. The 1990s (and early 2000s) saw a distinct interest in parts of the GIScience community to address this topic with agent-based modeling systems (Brown et al. 2005, , O'Sullivan et al. 2006, Waddell 2002) but it has been many years since any significant process has been made in this area.

(#5, Integration of processes in a region) finally, is the holy grail of geographic GIScience (to distinguish it from mere spatial or other specialized forms of GIS&T). It requires a very comprehensive perspective and a long-term research effort that does not fit well into today's funding scene. Among examples of such visions are the efforts of the Spatial Decision Support Consortium (2019) and of the National Geospatial Software Institute (GSI 2019). In both instances, however, there is no concerted action towards the development of standards for the interoperability of libraries of geographic processes, complete with interface definitions so that our process models can actually talk to each other. Cao et al.'s (2018) work is one of the few examples of such integrative, albeit not easily replicable work.

5. The Role of GIScience in the Age of Data Science

While the enthusiasm for geocomputational methods that have the potential of addressing some of Ackerman's research agenda items seems to be waning, data science is now promising to fill the gap by combining geospatial analysis with semantic modeling. The hyperbole of Anderson's (2008) 'End of Theory' is reminiscent of the broken promises of artificial intelligence of the 1980s. More promising is the notion of theory-guided data science (Karpatne et al. 2017), which marries contemporary technologies with the bodies of knowledge of applied disciplines – very much along the lines of what we expected from GeoComputation but this time based in a computational setting that is informed by geography and related disciplines. In addition to the exploratory tool chest of data science (Gray 2007) theory-driven data science's epistemology is suited to extracting additional, valuable insights that traditional 'knowledge-driven science' would fail to generate. Knowledge-driven science, using a straight deductive approach, has particular utility in understanding and explaining the world under the conditions of scarce data and weak computation. Geographic theory-driven data science (Faghmous and Kumar 2014, Miller & Goodchild 2015) is much more suited to exploring, extracting value and making sense of massive, interconnected data sets stored in Cloud-based libraries (Hey et al. 2009), fostering interdisciplinary research that conjoins domain expertise using a modern cyber infrastructure (as it is less limited by the starting theoretical frame). It hence leads to more holistic and extensive models and theories of entire complex systems rather than elements of them. Capturing these in a consistent semantic model should be an important part of our research agenda for the upcoming decade (Stoica & Peckham 2019).

Even more than science and technology being connected, the idea is that they are deeply and inextricably linked. Until recently, the agreed upon perspective was that science led to discovery, and then technology proceeded afterwards in application. But this is now neither satisfactory nor, in light of human impact on the Earth's systems and hence human livelihood, acceptable: "We seek solutions. We don't seek—dare I say this?—just scientific papers anymore" (Chu 2007). The idea of technoscience (Latour 1987) denotes a fundamental link between science and technology in in form of co-evolution, and co-production. This can be seen in many contemporary fields such as nanotechnology, synthetic biology, and climate studies, where it is impossible to separate the scientific from the technological.

The ontological characterization of data cannot be seen as a neutral, technical process; it is instead a normative, political, and ethical one: in other words, (GI)science is a social construct and not an objective absolute truth (see section 3). It therefore should not be understood as independent of the thought system and the instruments underpinning their production (Bowker & Star 2000). It is in this light that Kitchin (2014) proposes the idea of data assemblages, all the technological, political, social and economic apparatuses and elements that constitute and frame the generation, circulation, and deployment of data, that take these different influences explicitly into account.

This author has often argued that current GIS are little more than geometric information systems that concentrate on spatial rather than geographic aspects. To achieve the latter, it is necessary to move beyond the identification of patterns (which also happens to be a hallmark of data science) to move to additional analyses that are context-aware such as GIS-based computational modeling, agent-based modeling, or multi-criteria evaluation to name just a few. This is the main argument of critical GIS and radical statistics, and to a lesser degree behind the notion of mixed (quantitative and qualitative) methods popular in public health and social research, where methods and models are employed within a framework that is reflexive and acknowledges the situatedness, positionality and politics of the social science being conducted.

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