

Digital twins: The current “Krays” of urban analytics?

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Over 30 years ago, I attended a workshop on Spatial Decision Support Systems (SDSS) convened by the National Center for Geographic Information and Analysis.¹ Out of frustration at what I perceived to be a lack of focus at the workshop, I subsequently wrote a mildly scathing review of it, referencing the Golgafrinchans of Douglas Adams’ famed *The Hitchhiker’s Guide to the Galaxy* series (Adams, 1979; Fotheringham, 1990). For the new generation of urban analysts, the context of my reference was that a planet, Golgafrincha, decided to rid itself of its less-valued members (advertising executives, management consultants and the like) by shipping them all to a planet (which subsequently turned out to be Earth) where they were left to their own devices to reinvent basic necessities.² After thousands of years, the protagonist of the book revisits the planet to see how they are getting on with designing a wheel. Paraphrasing Adams, “Fine” they reply, “we’re making great progress – we’ve decided it’s going to be red”. The subtext of course, and the source of my frustration, was that the workshop reflected Golgafrinchan attitudes by seemingly valuing aesthetics above functionality.

In February, 2023, I attended, and indeed helped organize, a workshop convened by the Spatial Analysis Research Center (SPARC) at Arizona State University on Digital Twins (DTs) which left me with a sense of *déjà vu*.³ First, nobody managed to come up with an acceptable definition of a DT. Should a DT contain a feedback loop? Is a flight simulator a DT? Are navigational systems DTs?⁴ How much of reality should a DT replicate? Second, although the research presented was of a very high quality, it was clear that a Golgafrinchan mentality was in evidence in that a good deal of attention was paid to aesthetics over processes. Nowhere was this more evident than with the focus on 3-D representations of urban areas. Advances in this area are impressive with renderings being increasingly life-like and increasingly easy to manipulate even with basic computing tools. However, although such representations of cities are useful for assessing the visual impacts of proposed new buildings and for calculating indices based on building location, orientation, height, etc., such as those for shade, temperature, and airflow, they are essentially sterile when it comes to what humans do in cities. Without humans, DTs of cities have little meaning because cities consist of buildings and *people*. Of course, once you add the “messiness” of people, their annoyingly difficult-to-predict behavior, and their predilection for not having their personal details and whereabouts broadcast worldwide, the DT analogy starts to unravel. The behavior of humans, be it for traveling to work, going shopping, recreating, needing medical attention, having packages delivered, etc., is partially a product of apparent randomness and difficult to replicate, especially compared to

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buildings which are inanimate and largely unresponsive to stimuli.⁵ Human behavior is often difficult to understand in terms of motivation, responsiveness, repeatability, and homogeneity. It is clouded by variations in both our perception and cognition of the urban landscape. Anyone with knowledge of cognitive mapping knows that the way in which we, as decision-makers, view the urban landscape is not the same as reality or any 3-D rendering of that landscape, both of which assume no decay in knowledge as distance increases from the locations where we spend most of our time. So, adding behavioral *processes* to DTs of cities causes huge problems because what started out looking like a twin begins to look increasingly like a second or third cousin whose parental lineage is in some doubt. This has enormous implications for moving forward with spatial DTs because the term “digital *twin*” implies a level of veracity which is likely to be absent if we are talking about a true DT of a city; one which incorporates how human beings utilize various buildings, roads and other elements of 3D infrastructure. Given we seem not to have any great means of representing error in DTs, how do we convey the uncertainty in any replication of real behavior within a digital city?

Our often exaggerated expectations of the roles of DTs in understanding spatial processes are compounded by two related transitions: the move from well-defined systems to ill-defined ones; and the move from the aspatial realm to the spatial. The current craze for DTs stems, at least partly, from their success in well-defined and self-contained systems such as those often found in engineering and medicine—the functioning of a jet engine and a human organ being the usual examples. There are huge advantages to be able to subject components of an engine to varying levels of stress and to various combinations of circumstances that might result in engine failure without having to experience actual failure. The same logic holds true of flight simulators (who would want to practice avoiding crashes in a real aircraft?) and to the behavior of human organs. However, these are specific applications whose components are relatively well understood and which are not subject to the whims and apparent randomness of human behavior.⁶

The transition in the application of DTs from well-defined to ill-defined problems is often related to the transfer of ideas from the aspatial to the spatial domain. Whenever concepts, models, and techniques are borrowed from aspatial disciplines and applied to the spatial realm, a huge *Caveat Emptor!* sign should be attached. Spatial statistics, for example, are *not* aspatial statistics applied to spatial data and a GIS is not just a management information system applied to geocoded data. Both utilize the special properties of spatial data to create new tools which are distinguishable from their aspatial counterparts. The question with applications of DTs to the spatial realm is “*what’s the difference?*”. Is there anything special about the spatial realm that adds to the complexity of DTs and makes a spatial DT (SDT) fundamentally different from a DT? If there is no distinguishing metric, then we should drop the pretense that SDTs are somehow different from their aspatial counterparts.

Of course, the fundamental question related to SDTs is “what do we want to do with them?”. The popularity of DTs in the aspatial realm is that they can be used to predict what happens when an external stimulus is applied to the system, sometimes with catastrophic results. We can, for example, answer questions such as “what conditions bring about engine failure?” or “what causes the heart to go into fibrillation?”. A DT of a city without people can be used in this way only in a very limited sense such as asking whose views are most restricted if a tall building were to be erected, or which streets are most flood prone in the event of a storm surge. The more interesting normative questions relate to people—“what happens to traffic patterns if a section of highway is closed for 3 months?”; “whose health might be affected detrimentally should the go-ahead be given for the siting of a waste incinerator?” and “what happens to house prices if a new development goes ahead?”. This, however, brings about the paradox of SDTs: the more reality we introduce, the worse our predictions become. Cities are not real if they are devoid of people but introducing people into a digital city brings about unpredictable and seemingly irrational behavior which might be spatially heterogeneous and cohort-specific. If SDTs are to be anything more than an ephemeral means to publications and grants, they

need to incorporate realistic models of human processes. Unfortunately, there is little evidence of resources being allocated in this direction. To use an automotive analogy, we seem to be focused on building a car with a Lamborghini chassis and a Lada engine. As someone who has spent a lifetime modeling spatial processes in a GI Science environment, I increasingly have empathy with the Sumatran rhinoceros and the Californian condor—we are all endangered species!

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Notes

1. For those under the age of 50, the title of this Commentary references the Krays who were notorious twins who headed London's organized crime during the 1960s "Krays" is also a homonym of "Craze" which reflects the current interest in digital twins.
2. Today, Douglas Adams would certainly have added social media "influencers" and reality TV "stars" to this list!
3. This was actually the fifth workshop on this topic I had attended in the month of February, with the US National Academy of Sciences organizing the other four on various application areas, so this is clearly a "hot topic"—or "bandwagon", depending on your point of view.
4. Arguably, a strict definition is not necessary—after all, what is "Big Data" or "GeoAI"—but not having a definition certainly makes it more difficult to have a meaningful discussion of the subject!
5. Exceptions including flooding and earthquakes.
6. However, even in medicine there is an increasing awareness that a "*one size fits all*" mentality is inappropriate in many circumstances and that personalized DTs are needed because each human being reacts slightly differently to the same medical practices.

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