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Societal Implications of Spatial Data Science

Advancements in computing, internet and geospatial technologies have led to an unprecedented surge in the production and consumption of geo-referenced data.

Simultaneously, the popularity of smart phones, Google Maps platform and Microsoft's Virtual Earth has led to ubiquitous mapping. Widespread implementation and use of sensors and geospatial technologies for administration and governance in both the western and nonwestern world has proliferated. Crowdsourced data is mined constantly with positive and negative intentions. Meanwhile, we are increasingly relying on AI to harness big data. GIS/T is thus a massive, global enterprise, used by governments, corporations and individuals. Given the centrality of human involvement in the production of spatial data/technologies, it is important to highlight how humans shape/are shaped in such interactions. It is important for us to also highlight the socially constructed nature of spatial data science, to understand that scientific innovations and breakthroughs occur due to a process of social interactions.

Our research must consider the complexities of human interactions with spatial data science. Varying social, political, economic, cultural, institutional and organizational contexts and varying cognitive abilities shape the choices and ways of geospatial data/technologies being used. Human interaction with computers as an individual and as a group are subjective and highly contextual. An individual's interaction with geospatial data/technologies is shaped by one's spatial literacy, comfort with technologies, cognitive abilities, cultural norms etc. For non-western societies, proficiency in English language and Western scientific knowledge are also significant. Such factors also shape a group's interaction with GIS. Participatory GIS research examines how historically marginalized groups use spatial knowledge to advance their identities, contest inequalities, and challenge power hegemonies.

By unpacking the complex, contingent and localized nature of participation and data/GIS use, we gain a nuanced understanding of how individuals or community groups interact with spatial data/geospatial technologies. Because of variable outcomes, we cannot rely on a "one-size fits all" approach. Instead, we can create alternate geospatial technologies with more intuitive software designs and different functionalities that fulfill the needs of the marginalized groups. We must also attend to alternate forms of representation and better integration of qualitative and quantitative knowledge. Linguistic and cultural differences similarly shape human interactions with spatial data science. Further, adoption and use of GIS in the non-western world must be examined to understand the challenges and impediments. Below, I highlight key issues in Participatory GIS that are significant in future spatial data science research:

1. Designing alternate, low cost, geospatial technologies for participatory GIS: Global popularity of participatory GIS and VGI activities highlights the significance of democratization of geospatial technologies among non-experts. A true democratization

   of spatial data science can only occur if we address the needs of different non-expert user groups. For many, both cost and software complexity are barriers. Here, appropriateness of proprietary software is significant, as both design and functionalities are shaped by the needs of the dominant market segment. Development of FOSS4G has addressed some concerns, but we must also address software design issues. Traditional GIS design is non-intuitive and frustrating for users not trained in GIS. Low cost, intuitive and appropriate geospatial technologies containing analytical functionalities suited to the needs of marginalized communities/citizens must be prioritized. Geo-web offers great potential for such alternate GIS, especially as data storage in cloud reduces the cost barrier.

2. Addressing alternate conceptions and representations of space (not based on traditional map formats/ geometric views) within a GIS: Alternate representations of space must be prioritized in a GIS, as geometric views are cognitively difficult to non-experts and those lacking spatial literacy.
3. Addressing Quantitative/Qualitative data integration: Greater/better integration of two types of data is necessary in PGIS/VGI, as these actively include qualitative data.
4. Depicting complex and ambiguous social and physical space within GIS.
5. Incorporating linguistic/cultural diversity in GIS particularly in the non-western world: We rarely examine the needs of the non-western world, despite their prolific use of ICT/GIS. Cultural and linguistic diversities must be considered in our research agendas. Design of software must also be linguistically/culturally diverse.
6. Addressing the role of AI in PGIS and VGI practice

Further, we must grapple with the issues of replicability and reproducibility (R&R) in spatial data science. Such requirements are particularly challenging in inquiries of human/geospatial technology interactions, owing to the socio-political-cultural-linguistic-cognitive differences. Consequently, research outcomes are quite unpredictable. Yet, I see the lack of R&R as a strength and not a weakness. Such an approach understands that errors are a result of individual differences. Ultimately, the impossibilities of attaining perfect R&R are rooted in the differences in epistemology and ontology that exist in "hard" science and human centric research.

Relevant References

Ghose, R. 2001. Use of Information Technology for Community Empowerment: Transforming Geographic Information System into Community Information Systems*. Transactions in GIS* 5(2): 141–163

Ghose, R. and Welcenbach, T. 2018. "Power to the People": Contesting Urban Poverty and Power Inequities through Open GIS. *The Canadian Geographer* 62(1): 67–80.

Goodchild, M. (2007). Citizens as sensors: the world of volunteered geography. *GeoJournal* 69: 211–21.

Garnett, R and P. Kanaroglou. 2016. Qualitative GIS: An open framework using SpatiaLite and open source GIS. *Transactions in GIS* 20(1): 144–159.

Rey, S. J. 2009. Show me the code: Spatial analysis and open source*. Journal of Geographical Systems* 11(2): 191–207.