On the Epistemological Aspects of Geo-Computational Thinking and Curriculum Design

Ningchuan Xiao
xiao.37@osu.edu
Department of Geography, The Ohio State University
Columbus, Ohio

ABSTRACT

What should we teach students who are interested in geospatial data science and what should an undergraduate or graduate curriculum in this area look like? This paper addresses such issues from an epistemological perspective and discusses the critical linkages among different fields that are related to geo-computational thinking.

CCS CONCEPTS

• **Social and professional topics → Computational thinking**; **Information systems education**.

KEYWORDS

geo-computational thinking, curriculum design, actionable knowledge, levels of abstraction

ACM Reference Format:
Ningchuan Xiao. 2019. On the Epistemological Aspects of Geo-Computational Thinking and Curriculum Design. In *1st ACM SIGSPATIAL International Workshop on Geo-computational Thinking in Education (GeoEd'19), November 5, 2019, Chicago, IL, USA.* ACM, New York, NY, USA, 2 pages. https://doi.org/10.1145/3356393.3365372

It is undeniable that the popularity of Python is ever growing in the field of data science. On top of this trend, many software venders have implemented numerous application programming interfaces (APIs) or development kits for users to utilize the functionalities of the software. Some of the general packages include numpy, pandas, and TensorFlow, and special packages involving geospatial data and analysis include geopandas, PySAL, and arcpy. There is an obvious benefit of this trend: a regular user can start to use any of these packages almost immediately when they find it and finish those easy-to-follow online tutorials. This trend also begs a question: is the teaching of geo-computational thinking relevant or even necessary? A follow-up question is about the need of training in computer science: should today's students in non-computer science disciplines learn core computer science concepts?

To address these questions, it is important to reasonably position geo-computational thinking. Let us start by defining geo-computational thinking as a process of using computational methods to generate actionable geospatial knowledge. Such a definition is not provided as an assertion. Instead, it is made to start a conversation. Here, actionable knowledge [1] refers to propositions that cause actions that will in turn make actual and effective real-world influences. A simple form of actionable knowledge is decision making, a process of finding alternatives that will be adopted by an organization or by individuals as a plan of action. Some examples with geographic components are whether a new industrial facility should be located at a certain place, or an individual finds the best commuting route for a certain day.

The entire process of geo-computational thinking involves various levels of abstraction. The first level of abstraction is how the reality is transformed into data. A data model is often required to make such a transformation, which is referred to as representation in the geographic information science (GIScience) literature [4]. In general, a space-time-attribution (STA) tuple of $\{x, t, a\}$ can be used to ultimately represent the geographic phenomenon in location x at time t with a set of attributes a. Different computer science theory and methods are essential to develop efficient data structures to encode the STA tuple. However, in order to understand the effectiveness and consequences of the data, it is critical to understand the data models, and therefore the theory and methods in GIScience.

The next level of abstraction is modeling, a process of developing computational models to solve problems with geographic components. While it may seem that everyone can build a model, it is reasonable to argue that an effective model, one that exhibits external validity, can only be built with the understanding of the system being modeled. Such an understanding can be considered as a metamodel that can

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than ACM must be honored. Abstracting with credit is permitted. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee. Request permissions from permissions@acm.org.
GeoEd'19, November 5, 2019, Chicago, IL, USA
© 2019 Association for Computing Machinery.
ACM ISBN 978-1-4503-6952-7/19/11…$15.00
https://doi.org/10.1145/3356393.3365372

be used to specify and guide the development of the actual model. Developing models requires the design of efficient algorithms [2], and the metamodel can help us understand the input and output of the model under various domain specific conditions such as uncertainty [3] and error [5].

In the above short discussion, we elaborate on the epistemological essence of geo-computational thinking. In summary, geo-computational thinking is in the intersection between computer science and geographic domain knowledge. It should be clear that programming is important but it should not replace what a formal and thoroughly designed curriculum that covers important topics from both disciplines. While it is important for students to acquire certain skill sets so that they can be competitive in job markets, as educators we should also have a clear picture about what makes geo-computational thinking and why it is important for students to receive complete training. The challenge is to identify what concepts are in the intersection, and more importantly, how different concepts from the two different fields can be cohesively combined into the curriculum design process. It will be necessary for workshops like GeoEd 2019 to take a leading role in this direction.

REFERENCES

[1] Chris Argyris. 1996. Actionable knowledge: Design causality in the service of consequential theory. *The Journal of Applied Behavioral Science* 32, 4 (1996), 390–406.
[2] Thomas H. Cormen, Charles E. Leiserson, and Ronald L. Rivest. 1990. *Introduction to Algorithms.* The MIT Press, Cambridge. 1028 pages.
[3] Michael Goodchild and Sucharia Gopal (Eds.). 1989. *Accuracy of Spatial Databases.* Taylor & Francis, London. 290 pages.
[4] Michael F Goodchild, May Yuan, and Thomas J Cova. 2007. Towards a general theory of geographic representation in GIS. *International journal of geographical information science* 21, 3 (2007), 239–260.
[5] Stan Openshaw. 1983. *The Modifiable Areal Unit Problem.* Geo Books, Norwich. 41 pages.