Workshop on Teaching Spatial Thinking at the
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Thinking about Spatial Computing

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Abstract. We propose to include the perspective of spatial computing in interdisciplinary courses on spatial thinking. Specifically, we recommend developing and applying a set of spatial lenses through which learners of Geographic Information Systems (GIS) get to see geographic space and choose spatial computations. These lenses are based on the core concepts of spatial information proposed by the authors. While there is intentionally nothing new about the concepts per se, their explicit use as lenses through which to see geographic information and select GIS operations is innovative. Thus, we propose a lightning talk on core concepts of spatial information as a form of spatial thinking to support learning GIS.

Keywords: spatial computing, spatial lenses, core concepts of spatial information, GIS learning

1 Our Perspective: Spatial Computing

Spatial thinking focuses on space as a medium to structure problems across disciplines, and is normally discussed in contexts of wayfinding or moving and arranging objects. When developing educational materials for spatial thinking, it is worth considering the spatial thinking that goes into spatial computing, i.e., the usage of formal models and technical tools to represent and process information. In particular, conceptualizing geographic phenomena requires the application of appropriate concepts, such as fields or networks, and this is a spatial thinking skill that gets taught less explicitly. There is broad consensus that choosing how to conceptualize geographic phenomena for analysis is a key spatial thinking skill [1]. Yet, GIS learners are often taught about data formats, file types, databases, and standards before learning to think about GIS contents. In other words, using a GIS is taught more through software thinking than through spatial thinking about contents.

As a consequence, GIS users are taught how to answer questions about geographic space by memorizing computational techniques to answer them, rather than by being presented with a way to think about questions that make sense on certain contents. The questions typically remain implicit and get lost in the necessary translation to the answering methods captured by GIS commands. For example, the question “which farms in some agricultural region are at risk from

a bird flu outbreak" needs to be translated into commands for computing bird density maps, which are then visually inspected for risk areas. The conceptualization of the question in terms of bird density surfaces is implicit and alternative choices (such as farm objects connected through social and transportation networks) are hard to think of.

2 Our Recommendation: Teaching through Spatial Lenses

One can view the conceptualization phase of a GIS project as a process of choosing lenses through which to look at geographic space. For example, a GIS user may need to decide whether to consider some terrain as a surface (with elevation values for any position, allowing for computations like slope and aspect) or as a network of peaks, pits, ridges and valleys (allowing for flow analyses). Each choice of a lens (field or network, in this case) comes with a set of suitable analysis operations (map algebra and network analysis). GIS user interfaces are currently designed without such explicit lenses, offering the users a bewildering collection of analysis operations cutting across different conceptualizations.

Based on this idea of spatial lenses, we suggest including a computational perspective in an interdisciplinary spatial thinking course. What spatial thinking informs the choice of spatial computations and how? How is that kind of thinking about geographic space best taught? As an answer to the first question, we suggest the previously published idea of core concepts of spatial information. Today's answer to the second question is, in practice, "through GIS commands". Instead, the answer could be "through the lenses of core concepts of spatial information". The core concepts have been defined in [2] and further specified in [3]. Figure 1 lists the terms adopted for them. A more extensive table with the computations proposed for each core concept is omitted here for space reasons and can be found in [3].

<table>
<tr><th colspan="5">Core Content Concepts</th><th>Core Quality Concepts</th></tr>
<tr><td rowspan="2">Location</td><td rowspan="2">Field</td><td rowspan="2">Object</td><td rowspan="2">Network</td><td rowspan="2">Event</td><td>Granularity</td></tr>
<tr><td>Accuracy</td></tr>
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Fig. 1. Overview of the core concepts of spatial information

The first results from testing the set of core concepts as a vehicle for computational spatial thinking in an undergraduate introductory GIS course at UCSB are encouraging. The course's learning outcomes include the ability to apply core concepts of spatial information to a variety of scenarios, and the technical competencies to answer spatial questions with computational tools. The idea for the

course was that students should learn about the kinds of questions they can ask a GIS before they study how to produce answers through often obscure system commands. The course design went hand-in-hand with further research on these core concepts. The learning of the core concepts was grounded by performing computations around each concept on local data from the UCSB Campus and surroundings.

3 Our Resources: An interactive tool, a book, open source code, and labs

To support our recommendation, we plan to provide the following resources for teaching an interdisciplinary spatial thinking course:

1. An interactive cube with lenses on its sides to see geographic information from six different perspectives;
2. A set of short introductory texts, as chapter drafts of a book on the core concepts underlying the lenses;
3. A GitHub repository[1] containing formal specifications of the core concepts and Python scripts to use the lenses for actual GIS queries;
4. A set of GIS labs organized around the core concepts.

These materials can be made available in any form deemed useful by the designers of the envisioned interdisciplinary spatial thinking course.

4 Conclusion

Our workshop contribution will be to make a case for spatial thinking in the teaching of spatial computing. We will present the idea of spatial lenses, defined by a set of core concepts of spatial information. The main idea of this approach is that computations need to be organized conceptually around the concepts they compute with. This is a step forward from past attempts of GIS designers and GIScience researchers to organize existing GIS commands in a bottom-up fashion. Ongoing work concentrates on refining the specifications of core concept computations and continuing the implementation of Python scripts to link them to existing GIS commands and spatial computing libraries.

Acknowledgments

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[1] `https://github.com/spatial-ucsb/ConceptsOfSpatialInformation`

References

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