GIS Interactive Web App on Core Concepts

AGILE Workshop Position Paper on Teaching Geospatial Technologies to All

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As a teaching assistant for GIS courses, the author witnesses the difficulties students face when using GIS software. The complicated hierarchical structure and hundreds of operations make GIS appear overwhelming to students. It typically takes a geography student a year's worth of courses to learn to use the software and commands productively. However, the mastering of software and data models does not in itself guarantee the judicious use of geographic information and spatial analysis. Furthermore, the rapid growth in geospatial data has made these data more and more popular among researchers and practitioners in diverse domains outside geography. For those potential users of GIS, the technical aspects dominating GIS courses, such as how the data is stored, are of little interest. Kuhn's (2012) *core concepts of spatial information* can help teach GIS more effectively and make GIS easier to learn for a wider range of users. I will present an experimental interactive web app based on a well documented case study to support and further explore my position.

The idea behind the core concepts is to shift from traditional teaching of GIS, based mainly on software commands and data models, to teaching based on spatial questions posed in terms of the *core concepts of spatial information*[1]. Outside the GIS context, we ask spatial questions and use spatial thinking every day. "Where is the nearest gas station?" "What is the shortest route to campus?" We get used to asking and answering spatial questions without even noticing it. Yet, when using GIS, users have to switch from this natural mode of inquiry to one that is loaded with (and often obscured by) technical jargon. The core concepts of spatial information are specified by the basic spatial questions users can ask a GIS about an environment. Thus, teaching through core concepts should make GIS easier to learn, understand, and judiciously apply across disciplines.

The interactive web app I developed demonstrates how to ask spatial questions in terms of core concepts of spatial information, and how answers can be computed on a common spatial computing platform. Figure 1 shows the interface of the web application WACC (Web Application on Core Concepts) . The web app was developed using Shiny[2], which is an R package to build interactive web apps. The reasons for using Shiny are the following:
1) R has an active and growing spatial analysis community;
2) Developing the user interface and spatial processing in the same environment (R) is convenient and reduces complexity for both developers and users;

[1] http://spatial.ucsb.edu/core-concepts-of-spatial-information/
[2] https://shiny.rstudio.com/

3) The approach of translating core concept questions into spatial computations can easily be migrated to other spatial computing platforms, including GIS APIs

The web app can be used as an introductory tool to help students understand the core concepts without them needing to know implementation details, so they can focus on the conceptual understanding. For example, if students want to know the attribute value in a field for a specific position, they can use *get value* to answer this question; similarly, they can use *relation* computations to find out the spatial relationship between two objects. Students do not have to worry about the underlying mechanisms of storing and manipulating the data (such as raster or vector data models), they will be able to focus on their spatial questions and how to have GIS answer them. Contrast this with current GIS teaching and learning, where students are introduced to data models such as raster and vector, and numerous specialized and format-dependent software commands, hindering their progress toward understanding what a GIS can do and how to use it.

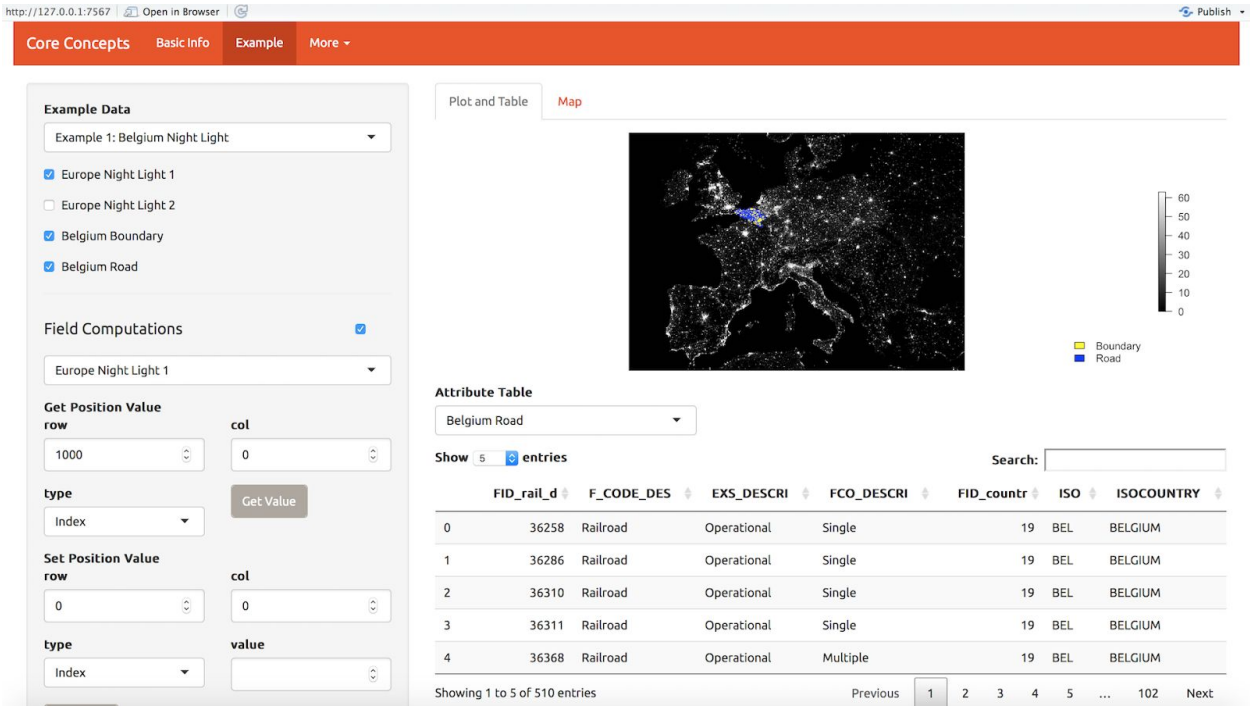

Figure 1. The web application interface of core concepts implemented by Shiny (R).

To illustrate the idea, I use a case study called “Belgium night lights”. It follows the practice in economics to use nocturnal luminosity as a proxy measure for industrial development, based on the idea that the lighter a region appears on a satellite image, the higher its level of economic activities. In an example used at MIT (Lowe, 2014), the question asked is *What was the luminosity near the road in China without gas flare in a coarser resolution?* We can use core concepts and the interactive web app to ask this question in a concise manner, rather than in roughly a dozen steps. I chose Belgium as the study area, as it is less computationally expensive (considering the area of the country and the complexity of the road network), but the

question remains the same regardless of the study area. We can decompose the question into four core questions shown below.

- What is 0.5 degree distance road extend?
    - *object* - buffer
- What is the average luminosity of two satellite images?
    - *field* – map algebra
- What is the average luminosity in a give extent from step 1 and 2?
    - *field* – set domain
- What is the mean luminosity at a coarser granularity?
    - *granularity* - coarsen

The questions can be easily asked in and answered by the interactive web app, and the result is shown in figure 2.

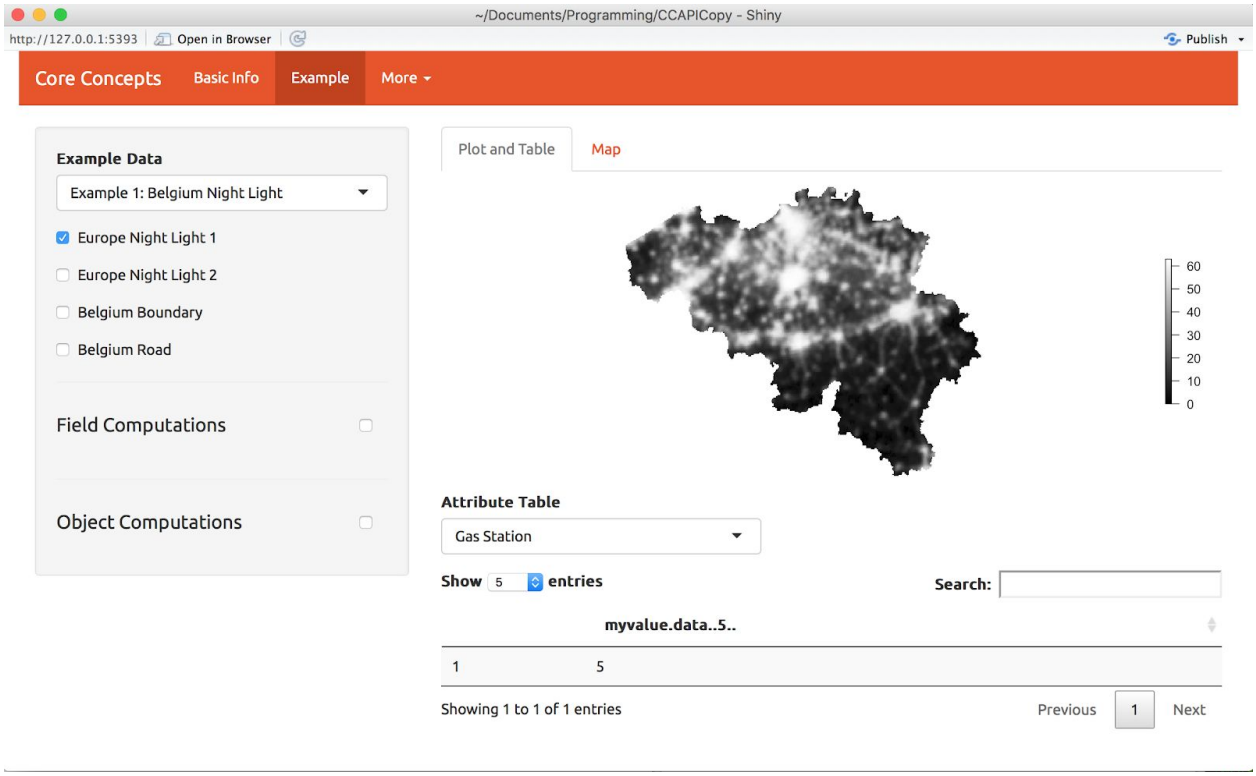

Figure 2. The result of Belgium night light.

The web app is currently implemented for the *field* and *object* concepts and can be extended to other concept concepts, *network* and *event*. The application can also be modified to cover other case studies.

Reference

Kuhn, W. (2012). Core concepts of spatial information for transdisciplinary research. *International Journal of Geographical Information Science*, 26, 2267-2276.
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