The idea behind the book

Imagine you are considering a hike and asking yourself questions like these:

A. How long is this trail?
B. How steep is it?
C. Does a bus go near it?
D. Can I get back before dusk?

Answers to such spatial questions provide spatial information. For example, an answer to the third question could be „Take bus 13 to the last stop“, from which you would learn something about the location of the trailhead in relation to the bus network.

Most spatial questions and answers are actually about space *in time:* the current length and slope of the trail; today's bus schedule; the hike's end preceding dusk tonight. Space is our focus in this book, but time is always in the background and sometimes moving to the foreground, such as in question D. We focus on *geographic* spaces, i.e., the physical and social environments where current, past, and future human activities take place.

Figure 1 (tbd): Geographic spaces and information about them
a: a trail with its length, b: the profile of the trail,
c: bus 13 near the trailhead, d: the hike and dusk periods on a clock

The idea behind the book is that all spatial information is about one of only four views of space: *objects* in a space, *fields* of measurement values across a space, *networks* connecting objects, and *events* happening in a space. We refer to these views of space as the *content concepts* of spatial information, because they capture what spatial questions and answers are *about*.

Table 1: Spatial questions and what they are about

Questions	**Asking about**
How long is this trail?	the value of the *object property* trail length
How steep is it?	the overall tendency of the *field* of slope values along the trail
Does a bus go near it?	a path through the *network* of bus routes
Can I get back before dusk?	the hike *event's* end time in relation to today's dusk *event*

Because the content concepts represent different views of space, they are best understood as *conceptual lenses* on the world. They capture distinct ways in which humans think about space, and we use them to organize spatial information (answers to spatial questions) and the computations to produce it.

Figure 2 (tbd): A hike seen through the four content lenses

Spatial questions may come with expectations on how good the answers should be. All answers to spatial questions are approximate, but how approximate can they be to still serve the purpose? How does this change, for example regarding steepness, if the questions are asked by a wheelchair user?

We address such considerations about the quality of spatial information through a second level of questions. These are questions about the information itself, in terms of three quality aspects: the *granularity* or level of detail in an answer, its *accuracy* relative to what is considered correct, and the *provenance* of the data and computations used to produce the answer. Table 2 shows four pieces of spatial information (in the form of answers to our spatial questions), followed by *quality questions* about the information, and finally by the *quality concepts* used.

Table 2: Quality questions and concepts

Spatial information	**Quality questions**	**Asking about**
This trail is 15 km long.	Is this really the length and not just the distance between the start- and endpoints as the crow flies?	the *accuracy* of the length information
	In what increments are trail lengths reported? (e.g., 0.1, 1, or 5 km)	the g*ranularity* of the length information
The trail has grade 8.	For what horizontal intervals are slope values calculated? (e.g., 100 ft)	the g*ranularity* of the slope information
	How much of the trail might be steeper than grade 8 (or 8%)?	the *accuracy* of the slope information
Bus 13 ends at the trailhead.	Was a valid bus schedule used?	the *provenance* of the *data* about buses
Leave before 11am to return before dusk.	What hiking speed was assumed?	the *provenance* of the *computed* hiking time

Whereas the content concepts are conceptual lenses on space, used when asking questions about it, the quality concepts can be seen as conceptual lenses on spatial information. Each quality concept represents an important view of spatial information quality, used when asking questions about it. Thus, the concept of granularity serves to find out how detailed some information is; the accuracy concept helps determine whether or to what degree some information is correct; and the provenance concept traces answers to the data and computations that went into them.

The book as a whole explains how the four content and three quality concepts shape spatial information, make it understandable. They can help reduce the complexities in designing, teaching, learning, and using Geographic Information Systems (GIS) or related technologies. To the best of our knowledge, the book is the first integrated and comprehensive treatment of spatial questions, spatial information, spatial computation, and spatial information quality.

To convey the essential role we assign to the content and quality concepts, we call them jointly the *core concepts* of spatial information. For a concept to qualify as *core* in our view, it had to be

I. *underpinned by commonly accepted theories* of spatial cognition and computation;
II. *implemented in commonly available software* used to answers spatial questions;
III. *situated at the same level of abstraction* as the other concepts.

These criteria resulted in a rational—though certainly debatable—choice of a small set of concepts. (An online collection of Frequently Asked Questions explains why we excluded certain concepts or relegated them to other abstraction levels). All core concepts should be at least vaguely familiar to people trained in some form of location-based computing. We are confident that, as a whole, they are sufficiently complete to ask all questions that can be answered by current and future location-based technologies.

The book's seven main chapters, one for each core concept, all have the same three sections:

1. *Questions* using the concept;
2. *Data* representing the concept;
3. *Methods* to compute answers.

These main chapters are preceded by a summary of the scientific and technical *Foundations* we rely on, and followed by an *Outlook* that illustrates by example how the concepts also apply to non-geographic spaces, such as human bodies, mechanical devices, molecules, or galaxies. We hope you will find our concise presentation compelling and helpful in understanding important aspects of the world through spatial information.