What is Field and Object Information?

Werner Kuhn

Department of Geography
Center for Spatial Studies
University of California at Santa Barbara
Asking spatial questions is too hard

<table>
<thead>
<tr>
<th>System Toolboxes</th>
</tr>
</thead>
<tbody>
<tr>
<td>3D Analyst Tools</td>
</tr>
<tr>
<td>Analysis Tools</td>
</tr>
<tr>
<td>Cartography Tools</td>
</tr>
<tr>
<td>Conversion Tools</td>
</tr>
<tr>
<td>Data Management Tools</td>
</tr>
<tr>
<td>Editing Tools</td>
</tr>
<tr>
<td>Geocoding Tools</td>
</tr>
<tr>
<td>Geostatistical Analyst Tools</td>
</tr>
<tr>
<td>Linear Referencing Tools</td>
</tr>
<tr>
<td>Multidimension Tools</td>
</tr>
<tr>
<td>Network Analyst Tools</td>
</tr>
<tr>
<td>Parcel Fabric Tools</td>
</tr>
<tr>
<td>Samples</td>
</tr>
<tr>
<td>Schematics Tools</td>
</tr>
<tr>
<td>Server Tools</td>
</tr>
<tr>
<td>Spatial Analyst Tools</td>
</tr>
<tr>
<td>Spatial Statistics Tools</td>
</tr>
<tr>
<td>Tracking Analyst Tools</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
Which farms are at risk from a bird flu outbreak?
Organizing questions around core concepts

location
field
object
network
event

granularity
accuracy

Towards a high-level GIS language

- I propose two “modules” of a high-level language for asking and answering questions about fields and objects.
- They are implemented as Haskell type classes and currently being translated to GIS calls in Python.
- Basic questions about the nature of fields and objects (in spatial information) turn out to be unsettled.
Fields (1)

1. are fields in the world, in our minds, or in information systems?
2. are they characterized by functions or relations?
3. are they defined over discrete or continuous spaces or both?
4. do they have a granularity?
5. how many dimensions can the spaces have?
6. can there be operations for field combinations?
7. can land cover be conceptualized as a field?
class FIELDS field position value where

getValue :: field position value -> position -> value
setValue :: field position value -> position -> value -> field position value

domain :: field position value -> Geometry

neighborhood :: field position value -> position -> Geometry

zone :: field position value -> position -> Geometry

local :: field position value -> (value -> value') -> field position value'

focal :: field position value -> (position -> value') -> field position value'

zonal :: field position value -> (position -> value') -> field position value'

instance FIELDS Array P2 String where

getValue a p = a!p
setValue a p v = a ++ [(p, v)]
domain a = geomFrom2P2 (bounds a)
local a f = fmap f a
1. are objects in the world, in our minds, or in information systems?
2. do they always have boundaries?
3. what is the essence of an object?
4. are features objects?
class Eq object => OBJECTS object where

  bounds :: object -> Geometry
  get :: (object -> value) -> object -> value
  is :: (object -> object -> Bool) -> object -> object -> Bool

get property = property
is relation = relation
Conclusions

1. fields and objects (as two fundamental notions in GIScience) are less clearly understood than we might wish
2. a key reason for disagreements and confusion is the frequent blurring of reality, conceptualizations of it, and implementations
3. axiomatic and testable formalizations help to distinguish both, to clarify the notions, and to organize GIS functionality
4. the presented specifications are meant to be improved!
5. back to bird flu: we also need transformations from objects (turkey farms) to fields (infection risk).
The way forward

1. a computational theory of asking (and answering) spatial questions
   • starting from executable specifications of core concepts
   • map to any GIS, R, Oracle, SciDB…

2. cloud computing architectures for application domains
   • declarative (rather than procedural) API’s: what, not how
   • in terms of domain concepts (farms and risk, not objects and fields)
   • developed and tested in cooperation with domain specialists

3. spatial computing courses starting from core concepts
   • introductory GIScience course (176a) at UCSB
   • micro-insertions in epidemiology, history, biology, political science, … courses
   • a MOOC?
   • all of this in the spirit of an “outward-looking GIScience”.
Thank You!

MUSIL

Eric Ahlgren, Andrea Ballatore, Austin Grove