Exploring the life of screen objects

EXPLORING THE LIFE OF SCREEN OBJECTS[1]

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ABSTRACT

This paper explores the metaphor 'screen objects are alive' for the purpose of zooming on geographic data at multiple levels of abstraction. In order to trace objects through multiple levels of detail we need to determine the areas these objects are associated to. This information is extracted from a partition tree. The paper first explains how to derive this partition tree. Then we define different lives of an object and show that they correspond to characteristic generalization operators. Analyzing life spans of (geo)graphical objects on screens throughout scale changes is crucial for the design of intelligent zooming mechanisms. It allows for the design of databases that are able to support highly dynamic user interaction in complex visualization tools.

1. MOTIVATION

Humans perceive, conceptualize and deal with the world at multiple levels of detail (Marr 1982, Minsky 1985). The need for a multilevel and multiperspective approach for geographic visualization is recognized in the Geographic Information society (Buttenfield and Delotto, 1989; MacEachren 1995). However, solutions how to handle multiple levels of detail in data structures or in user interface tasks like zooming are still missing. A good metaphor facilitates to find structures and operations for multiple levels of detail. This paper explores the metaphor 'screen objects are alive' for the purpose of zooming on geographic data at multiple levels of abstraction.

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The metaphor of life is a new metaphor for the operation of zooming. In the metaphor ‘screen objects are alive’ we consider the dynamic process of zooming the contents of a display. Objects are born when they are first represented on the screen. They die when they disappear from the screen. These changes (being born and dying) as well as other transformations occurring during scale change have been called ‘catastrophic changes’ (Mueller, 1991).

We assume that the database contains data in multiple levels of resolution. When zooming in the object in focus appears on the screen, then grows larger and larger, perhaps splits into several objects and finally is too large to be in focus. Another smaller object, that was part of the original object, now becomes the focus. In the other direction, zooming out, the object shrinks, becomes smaller and smaller until it disappears. Our objects change on the screen because we change their level of resolution when we zoom in and out.

In this paper we analyze how screen objects behave when zooming. We use a scanned map series from former East Germany as test data. The representations of the objects change with scale. In a GIS, there are other operations that can cause screen objects to change, e.g., reselection of topic, temporal change, or panning. In this work we are only concerned with the operation zooming, while theme, time and space are fixed. This excludes specifically multi-topic zooming from the scope of this paper (for works on thematic zooming see Volta 1992). The area of space that is radially the farthest from the focus of the zoom disappears when zooming in. This is, because we also consider the display window to be fixed in its dimensions.

Analyzing life spans of (geo)graphical objects on screens throughout scale changes is crucial for the design of intelligent zooming mechanisms (Bjorke and Aasgard, 1990; Timpf, to appear; Timpf and Frank, 1995). It allows for the design of databases that are able to support highly dynamic user interaction in complex visualization tools (Goodchild 1990).

The remainder of this paper is organized as follows: section two explains how we partition space to create objects and traces objects over three scales. Section three presents the partition tree we use to store object changes. Section four explains that metaphors help us in structuring and understanding our area of research. It also examines the results of section three in the light of the metaphor ‘screen objects live’. Section five gives conclusions and proposes future work.

2. WHAT ARE OUR OBJECTS?

In this paper we analyze and describe objects that were captured from a series of maps from prior East Germany. The maps have been scanned with non-professional equipment and saved as TIF files. Our examples are drawn from the areas of Alsleben/Saale and Berneburg/Saale. The map scales considered are 1:10 000, 1:25 000, 1:50 000, and 1:100 000. The last three were created with the same symbolization scheme.

In this section, we assume that our screen objects show the same behavior and structure as map objects. Although this is not a requirement of our model, it is the only practicable way to observe objects over several scales. We first explain how to subdivide map space and how to derive objects from that process. We then trace map objects over three scales and create their respective partition trees.

2.1 Map space is a container

We regard map space as a container, that contains more containers. This hierarchical arrangement of containers (Fig. 1) can be represented as a tree and corresponds to the vertical zooming hierarchy.

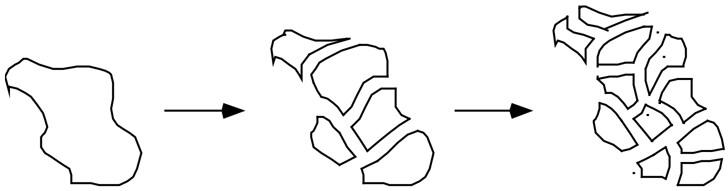

Fig. 1: Hierarchy of containers

At each level of the tree the set of containers is a complete partitioning of map space. One possibility for a complete partitioning of space is the subdivision into administrative units. Administrative units are arbitrary partitions of space, they do not reflect the underlying structure of space. From a visual point of view, those lines that are black and broad give a first subdivision of space. Lagrange (1994) and Bannert (Bannert, 1996) have proposed a division of space with the help of the street network. This idea is taken up and extended here: We divide space by the hydrographic network, the train network, and the street network. We start with the network that is preserved the longest in each of the three mentioned classes (Fig. 2). The density of the network grows with scale when more rivers, railways, and streets are added to the existing network. The method requires a consistent division of space over all scales. This means that the lower levels need to be completely included in the higher levels. When using real maps this often presents a problem.

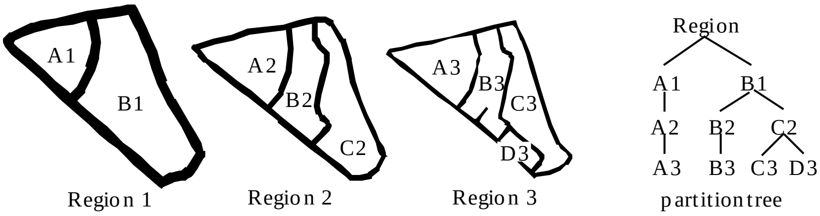

Fig. 2: Networks for spatial subdivision

The space between the lines of either network is considered a container. In the example (Fig. 2) we picked the same region in three different scales; the scale grows from left to right. In this particular case only the street network subdivides the space. Region 1 is a container that contains two areas A1 and B1. Region 2 contains three areas A2, B2 and C2. Areas B2 and C2 in region 2 correspond to area B1 in region 1. Region 3 contains four areas A3, B3, C3, and D3. Areas C3 and D3 in region 3 correspond to area C2 in region 2. In this example the partitions are consistent and can be represented by a tree (on the right in Fig. 2).

2.2 Contents of a container on several levels

The containers as defined above can either contain another partition of space based on the use of the area (e.g., industrial area), or objects like single houses and symbols, or both. In the following example (Fig. 3 through 5) four different areas have been identified. They are house block area, residential area, garden area, and non-designated area. The last three can contain objects like houses and symbols. Areas are determined either through a color change or through an existing boundary, that is not a street. If an area contains a street that divides the area into two or more separate areas, new containers are created. This means that there is another level in the partition tree.

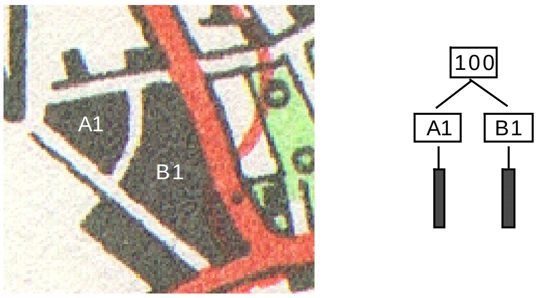

Fig. 3: Contents of a container (region 1 of figure 2)

The content of a container can also be represented by a tree. E.g., in figure 3 a high level container (called 100) contains two lower levels containers A1 and B1. Both A1 and B1 contain just one area, which is a house block area. The same region with more detail contains similar containers A2, B2, and C2.

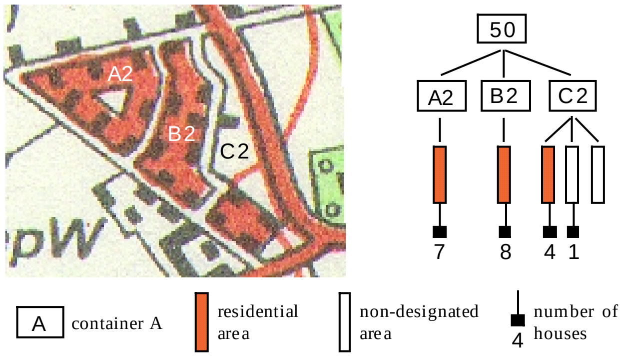

Fig. 4: Contents of a container (region 2 of figure 2)

The containers A1 and A2 cover the same area, whereas the containers B2 and C2 form a partition of B1. All of these containers contain other objects. E.g, the container C2 includes three areas: one residential area with four houses, one non-designated area with one house and one empty non-designated area.

Figure 5 shows again the same area with more detail than figures 4 and 3. There is a new container D3 in this example, that together with container C3 forms a partition of C2. In this last example we have omitted the tree description of container A3 for clarity.

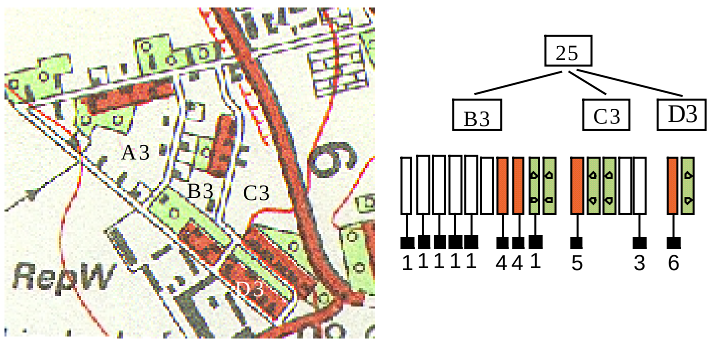

Fig. 5: Contents of a container (region 3 of figure 2)

The container C3 in figure 5 includes five areas: one residential area with five houses, two garden areas and two non-designated areas with one area containing three houses. The container D3 in figure 5 includes one residential area with six houses and a garden area.

These examples have shown that a consistent partitioning of space is possible. The results of this partitioning are three partition trees shown in the right hand side of figures 3, 4, and 5. In the next section we fit together the contents of all three partition trees according to their levels.

3. PARTITION TREE

In this section we determine how the combined partition tree looks like. The combined partition tree is necessary to trace objects over levels of detail and thus determine how they lead their live. The life of objects cannot be determined if the partitioning of space is not consistent or if some levels have ambiguous links to other levels. We have chosen an example where we can determine the life of objects. In figure 6 three partition trees are shown for container B1 and its partitions in regions 1, 2, and 3 respectively.

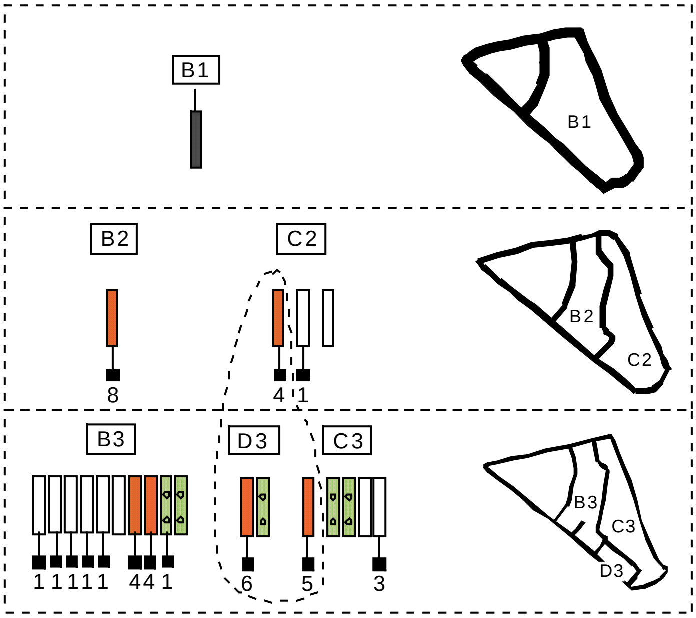

Fig. 6: Combined partition tree and corresponding regions

Figure 6 shows the partition tree in detail with its two levels and the corresponding regions. We already know from the partition tree in figure 2 that the container C2 in the upper level is subdivided into two containers C3 and D3 in the lower level. In the more detailed partition tree, we can see that the subdivision is not as clear. The residential area in C2 is split into three areas in the containers D3 and C3.

There are objects on each map that do not partition space in our model. Those are for example isolines, power lines, and embankments. These do not build containers (with exceptions of course, which we do not consider here).

Therefore we disregard in this paper isolines, power lines, embankments, and also labels. In the last case there are already working algorithms that can be applied to an otherwise finished product (Freemann 1991).

4. THE LIFE OF SCREEN OBJECTS

The partition tree in the previous section is the basis for our model of a life of objects. Objects from different levels of resolution are related to each other through the partition tree. The levels of the partition tree reflect the scale of the screen objects. While zooming, the scale continuously changes and with the scale the levels of detail change. We use the metaphor ‘screen objects live when zooming’ to express this relationship between scale change and time change.

4.1 Why use a Metaphor?

The metaphor of life is a new metaphor for the operation of zooming. In the metaphor ‘screen objects live’ we consider the dynamic process of zooming the contents of a display and observe how objects change in this process. Objects are born when they are first represented on the screen. They die when they disappear from the screen. Our objects change on the screen because we change their level of resolution when we zoom in and out. The time that passes during zooming (either in or out) is the time that our objects live. What is different from the life we know is, that we can move forward and backward in time by zooming in and then out again or the other way around.

Metaphors allow us to understand (sometimes only partially) one thing in terms of another. This does not mean that the two things are the same or even similar (Lakoff and Johnson, 1980). Metaphors are mappings of structure or behavior from a source domain to a target domain. For example the metaphor ‘life is a journey’ applies the notions of a journey to the notion of life. This is reflected in expressions such as ‘he is off to a good start’ or ‘its time to get on’.

Jackson has identified the need to understand the user interface operations of zooming and panning more deeply (Jackson, 1990) . Since most of our fundamental concepts are organized in terms of one or more spatialization metaphors. (Lakoff and Johnson 1980, p.17), we think that metaphors will help to understand the operation zooming.

Cartographers still struggle to understand the notions of scale and resolution (Kuhn, 1991). We think that the source domain of ‘life’ can be metaphorically applied to the target domain of ‘zooming’. This helps to understand the target domain and sheds light on the problem of scale.

When we interpret screens as dynamic views on data and not as static maps, we allow objects on the screen to change. In maps, things do not change.

They are static representations of a state of the world. As Kuhn (1991) has argued convincingly, the metaphor ’displays are maps’ is restricting the possibilities we have with current GIS systems (Moellering 1984, Robertson 1988). He proposes to use instead the metaphor ‘displays are views’. Views are dynamic representations and things may change in views. We go further in this metaphoric chain and say ‘changing things are alive’.

A similar metaphor has already been introduced by Buttenfield (Buttenfield, 1991) and pursued by Leitner (Leitner and Buttenfield, 1995). They talk about the behavior of cartographic objects over several scales. The goal of their study is to formalize rules about the behavior of cartographic objects. Our aim is to describe the behavior of screen objects with the help of a structuring metaphor.

4.2 Different Lives

The hypothesis for zooming out is that the object shrinks (shows less detail) until it is in its most abstracted state or prototype. The hypothesis for zooming in is that the object grows (shows more detail) until every detail known on this level in the database is displayed. Then, in both cases, a transformation (or catastrophic change) takes place and the same process repeats itself again.

We have found that a distinction between four different lives is necessary. Let us assume that we traced an object over several levels of detail starting from the most detailed representation. Let us further assume that the object is symbolized on the second level. On the third level the object disappears (see Fig.7).

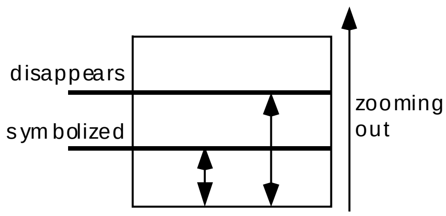

Fig. 7: Natural life and factual life

Natural life is the life a screen object would have if there were no cartographic rules. It would disappear the moment it is too small to be represented. In our example this would be the case after the first level. But the object is symbolized and thus its factual life is longer. The **factual life is** the life the object lives on screens thanks to the interpretation of a cartographer, who judges the object too important to be dropped. There are some objects that, by definition, will have different factual and natural lives (e.g. official buildings, important routes between cities etc.). Objects that are displayed as symbols are always prolonging their natural life. A symbolized object is leading an artificial life.

We also make a distinction between objects that live a short life and those that live a long life. The **short life** of an object lasts from its appearance to its disappearance on the screen as a *separate* object. In this life, the object dies when it is merged with others (zooming out). It also dies when it is split up into several objects (zooming in). When it is symbolized, it lives on (artificial life). The **long life** of an object is from the moment it appears up to the moment its last trace disappears from the screen. In the meantime the object can change several times through simplification, aggregation, symbolization, splitting, geometrization etc.

The definition of several lives of objects has shown that each life supports a different characteristic of screen objects in several levels of detail. It is part of future work to formally define these changes and their corresponding operations.

5. CONCLUSIONS AND FUTURE WORKS

In this paper we applied the metaphor of living = zooming to screen objects. We had to use existing maps in several scales as test data. We partitioned map space according to existing areas and built a partition tree for a map region in several levels of detail. With the help of the partition tree, we analyzed life spans of (geo)graphic objects. We found that several characteristics of screen objects can be captured by the definition of four different lives. These characteristics shed light on the problem of generalization but they also help to define and understand tools (especially zooming) for multi-resolution databases.

One important result of this study is that the partition trees need to be consistent in order to define the life of an object. This is often a problem with existing maps, which have not been created from the same scale and by the same person. It is necessary to find consistent test data, so that our study can be continued.

Future work in our research consists of formally defining partition trees and combining them into trees that span all levels of an object's life. After that it is necessary to formalize the currently defined lives and to verify the hypothesis that each of these lives supports a different generalization operation.

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