Digital Earth and Evolution of Cartography

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Abstract

Digital Earth is widely recognized as a new geospatial approach. However, there is no consensus about what exactly caused a new quality of the Digital Earth – the cutting-edge technologies, social practices or new scientific principle. In addition, relationship between Digital Earth and Cartography remains unclear. We propose to use the situational awareness as a platform for comparative analysis of different geospatial products and recovery of the internal logic of the evolution of the cartographic method. We demonstrate that Digital Earth is characterized by the use of another mathematical apparatus, rather than the classic cartography (similarity instead of the projection), and we offer our vision of the evolution of cartography, which led to the developing of Digital Earth.

Keywords: Digital Earth, cartography, neogeography, scientific visualization, sign

1 Introduction

Google Earth, launched in 2005, has become a new milestone in cartography and the first obvious example of the implementation of the concept of Digital Earth, foreseen a decade earlier by US Vice-President Al Gore [1]. The product was so innovative that beginning of "geospatial revolution" was proclaimed [2]. It was pointed out that the Google Earth differs substantially from classical maps – in particular, it does not use map projections†. The emergence of a new class of products, so-called "neogeography", distinct from the classic maps and GIS, was stated [4]. Nevertheless, the proposed definition of the neogeography was not offer a clear set of criteria to distinguish neogeography from classical cartography. It has been suggested that changes have occurred due to the use of new technologies and/or new social practices [5].

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† "Digital Earth implementations such as Google Earth avoided projections entirely by showing the Earth as seen from space" [3]
Obviously, Google Earth as a phenomenon includes new technologies and new social practices - such as collaborative GIS, crowdsourcing, etc. However, there are no exclusive new technologies and new social practices in Google Earth.

2 Analysis

Understanding the nature of the evolution of cartography requires a comparison of different approaches. The methodological basis for the comparative analysis of different geospatial solutions should provide the concept of situational awareness, which defines the conditions of effective perception of environment within its spatial and temporal contexts.

According to widely used definition, “Situational Awareness - the perception of elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future” [6]. It means situational awareness provided by (1) the direct, signless perception of the situation within (2) a single common framework that not divided into different scale-dependent replicas. These requirements are incompatible with the basic principles of classical cartography – layer representation, generalization and cartographic projection.

Layer representation means separation of the elements of real environment into a set of categories displayed on the map as an object layers by means of mapping symbols.

Generalization means the optimization of map symbols for specific map scale.

Figure 1. In cartography generalization leads to the creation of their own unique set of data for each scale, which distorts the geospatial context and destroys situational awareness

The use of map projections leads to irreversible reduction of the original dataset.

Map rigidly corresponds to specific scale (figure 1) and specific point of view. So using of maps leads to impossibility of multi-scale and multi-angle representation and, eventually, leads to unavoidable aberrations of perception and lack of situational awareness in hierarchical management systems. Therefore, demand for overcoming these constraints become a factor of evolution of cartography.

Demand for ensuring of multi-scale and multi-angle possibilities is the challenge facing classical cartography. Both problems were solved in Google Earth ad hoc. Therefore, we can reconstruct the evolution of cartography principle based on these demand.
The main obstacle to the implementation of multi-scale ability and multi-angle ability is the principle of generalization. It is possible to overcome this restriction by the transfer of general geographic context with the help of images – remote sensing data, e.g., aerial or satellite images. Same image can represent situation correctly in a very wide range of scales (figure 2). This idea has been implemented firstly in the so-called "geoportals" like Google Maps. However, Google Maps online service and other geoportals use map projections that prevent the implementation of the multi-angle ability, so this is a palliative solution.

![Figure 2. Raster images support multi-scaling, because of same image can support wide range of scales without generalization](image)

Map projection enables measuring with the help of external measuring unit (rule, curvometer, etc.). However, this is unnecessary when using a digital representation of the data, since in this case the measuring tools are integrated in the interface and it becomes possible to provide a measurement of all parameters without using the specific cartographic projections.

Accordingly, the next step is the ensuring of multi-angle ability, which is verso of the three-dimensional representation.

Three-dimensional (or 3D) visualization is a traditional approach now, but ensuring of situational awareness required single common dataset for Earth, allowing viewing the situation in any place in the world from any point of view and at any distance. It is possible within framework of mathematics of similarity (table 1).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Cartography</th>
<th>Digital Earth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics</td>
<td>Projection</td>
<td>Similarity</td>
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<tr>
<td>Datasets</td>
<td>Reduced</td>
<td>Unreduced</td>
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<td>Dimensions</td>
<td>2D</td>
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<tr>
<td>Measurability</td>
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<td>Unlimited</td>
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<tr>
<td>Situational Awareness</td>
<td>Limited</td>
<td>Full</td>
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Changing the cartography method is the basis for the understanding of the evolution of cartography from the maps to the Digital Earth and allows systematizing all variety of geospatial products in the proposed evolutionary model of cartography.

Accordingly, we propose the following definitions of different classes of geospatial products:
Map (first generation) - the reduced two-dimensional cartographic representation made for one scale and one viewing angle with the help of symbols;
Geoportal - palliative approach;
"Digital Earth" or "neogeography" (second generation) - unreduced three-dimensional cartographic representation that includes all variety of points of view and all variety of equivalent scales.

3 Conclusions

To Digital Earth belongs to second generation of cartographic products and based on similarity approach instead of projection approach. There are no exclusive technologies or social practices in the Digital Earth. Only the use of a new scientific principle (similarity instead of projection) provides a new quality for users.

In addition, phenomenon of Digital Earth can shed light on some problems of scientific visualization and semiotics.

Semiotics assumes that all images belong to a special class of signs – so called “iconic signs” [7]. This view leads to the identification of the mark and perception of what is false in general.

An alternative view suggests that direct perception is a signless perception. It means the introducing of the elementary concepts of signless information carrier - specific “zero-sign”, analog "zero" in mathematics [8]. In particular, this point of view can help to explain the nature of the high efficiency of scientific visualization.

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References