Scale in Immersive Virtual Environments

Florian Hruby [a, b] *, Rainer Ressl [a]

[a] *National Commission for Knowledge and Use of Biodiversity (CONABIO), Mexico City, Mexico, (florian.hruby, rainer.ressl)@conabio.gob.mx*
[b] *Department of Geography and Regional Research, University of Vienna, Vienna, Austria – florian.hruby@univie.ac.at*
* Corresponding author

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Abstract:

From a technical perspective, generalization, symbolization and scale have been defining criteria of mapmaking for centuries. From an epistemological perspective, these criteria have always been applied to generating insights from geospatial data through graphical representation.

Highly immersive virtual environments (HIVE) represent a fairly new geovisualization technology beyond these common criteria of cartography: At a ratio of 1:1 between physical and virtual reality the aforementioned principles of abstraction and reduction no longer seem to apply. Rather, geospatial data can be represented in VR at a level of detail and immersion that provides the IVE-user with a feeling of being there and moving around in virtually mediated place (cf. fig. 1).

Figure 1. Virtual representation (left) of real geodata (right). Scene from a HIVE of a Caribbean coral reef.

The representational power of HIVE challenges both cartographic praxis and theory: Practical issues arise, for example, from limited VR-capabilities of Geographic Information Systems (GIS). In order to make GIS data available on a VR headset, middleware is required (e.g. game engine software). Theoretical issues, as mentioned above, arise from the limited portability of cartographic core concepts, but also in regard of the user. So far, cartography has been visualizing spatial data “from outside”, i.e. from a third-person perspective, while users experience immersive environments rather “from inside”, i.e. from a first-person viewpoint.

In this paper, we will limit our considerations on the question of scale in immersive virtual environments. To approach this matter from different (incl. conflicting) viewpoints, several theses shall be discussed:

Thesis 1: Cartography is not about HIVE

HIVE can provide highly realistic representations of spatial reality at a 1:1 scale level. This characteristic alone, however, does not make them a cartographic service. Cartography focusses on the visualization of information implicit to spatial data (e.g. spatial patterns) while HIVE are rather explicit representations in terms of virtual reproductions of real world places. In order words, HIVE are merely qualitative, while cartography is usually interested in quantitative and quantifiable information. (It shall be noted, that a

similar argumentation could be applied to aerial images in particular, and photos in general: both accurately represent aspects of reality without being a cartographic product.) As HIVE cannot be considered as cartographic representations, the question of scale in HIVE is not a matter of cartography.

Thesis 2: HIVE have no scale

In the most general sense, scale can be understood as the proportional ratio between model and original. However, several meanings of scale are being used in the realm of digital cartography (e.g. level of detail or fraction). We can reduce these different concepts of scale to a common denominator: Scale expresses (explicitly or implicitly) the level of generalization (both spatially and thematically) of a cartographic model compared to the underlying real-world data. By contrast, HIVE provide un-generalized virtual replicas of real places, where the user has the experience of being situated in VR space, thus rather emulating than representing spatial reality. Consequently, it can be argued that the concept of scale (in any cartographically relevant sense) does not apply to HIVE. (It shall be noted, that thesis 2 is not necessarily a part of thesis 1. Tube maps and cartograms, for instance, have been subject of cartographic research for decades – even without a relevant notion of scale).

Thesis 3: HIVE are novel cartographic representations at a dynamic 1:1 scale level

A large body of research indicates that immersive VR-systems facilitate the user´s involvement with the issues visualized, thus leading to higher engagement and deeper understanding compared to non-immersive media. Since making spatial data understandable has always been a main objective of cartography, HIVE can be considered as geovisualization tools par excellence.

However, to maximize benefits from this new technique of representation, a broadening of cartographic key concepts is required. Regarding scale, we propose to define HIVE as three-dimensional 1:1 models, where the user perceives a VR representation of a real place at a level of detail as he would do being physically there. A 1:1 visualization facilitates the acceptance of the HIVE as the user´s preferred egocentric reference frame and, consequently, the formation of spatial presence.

In technical terms, HIVE require a dynamical rendering of all objects within the user's range of vision as a function of the distance between object and user. Even at a 1:1 scale level, objects closer to the user will have to be rendered at a higher level of detail (LOD) than objects in the visual background. As users of highly immersive VR-systems can move around in VR-space, range of vision and LOD of all objects have to be calculate on the fly. The 1:1 scale level of IVE is thus a dynamic rather than a static one.

Thesis 4: Scale in HIVE is spatio-temporal by definition

Users´ ability to move within VR-space is a defining criteria of HIVE. Since movement is change in position over time, scale in IVE cannot be reduced to its spatial dimension. Rather, HIVE represent at a 1:1 scale level both in spatial and temporal terms. Moreover, the user not necessarily has to be the only mobile agent in a VR environment. Also other actors can be considered regarding their movement and even behavior (e.g. animals) in terms of the aforementioned dynamic 1:1 scale.

The aforementioned theses (among others) shall be critically reflected in the light of our own practical and empirical experience on HIVE. We admit that not all of these viewpoints reflect our own comprehension of scale in immersive environments. However, we feel that a thorough discussion of different (incl. opposite) positions can only strengthen our understanding of the importance of scale on the cartographic research agenda.