Interaction primitives in 3D geovisualizations

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Introduction

The virtual environments and interfaces offer wide range of possibilities regarding not only sole representation of real world phenomena, but also their dynamic modification and customization. The typical representation of the real space is a geovisualization (map). As such, geovisualizations are widely used in practice. With the rising user demands the geovisualizations became interactive and fully adapted to specific users needs. Interaction with such virtual reality (VR) products consists of many specific types of action, however currently there is no uniform taxonomy for these basic units of interaction. With the growing number of VR products we need such taxonomy to better understand geovisualization. Interaction primitives (Roth, 2012) can offer such a framework.

We can further divide interaction primitives into three general categories according to their quality: **objective-based**, **operator-based** and **operand-based**. Below we provide existing examples of interaction primitives and establish new taxonomy for use in 3D virtual geovisualizations.

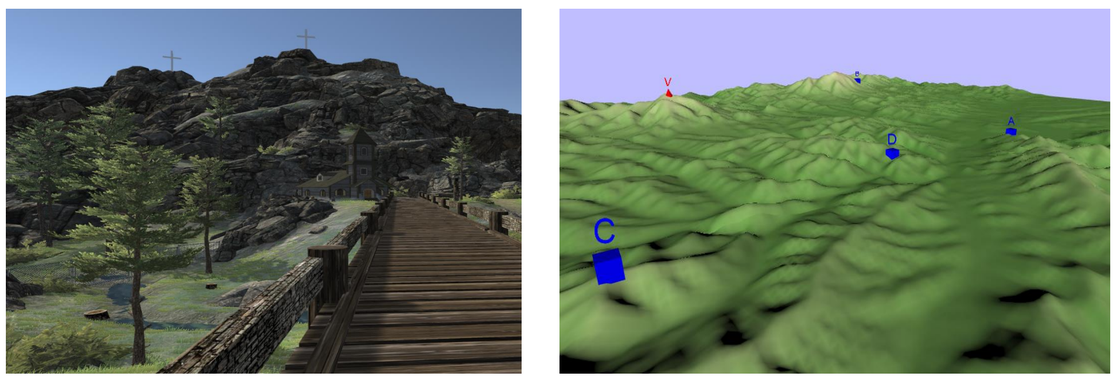

Fig. 1. Examples of 3D virtual geovisualizations

Interaction framework

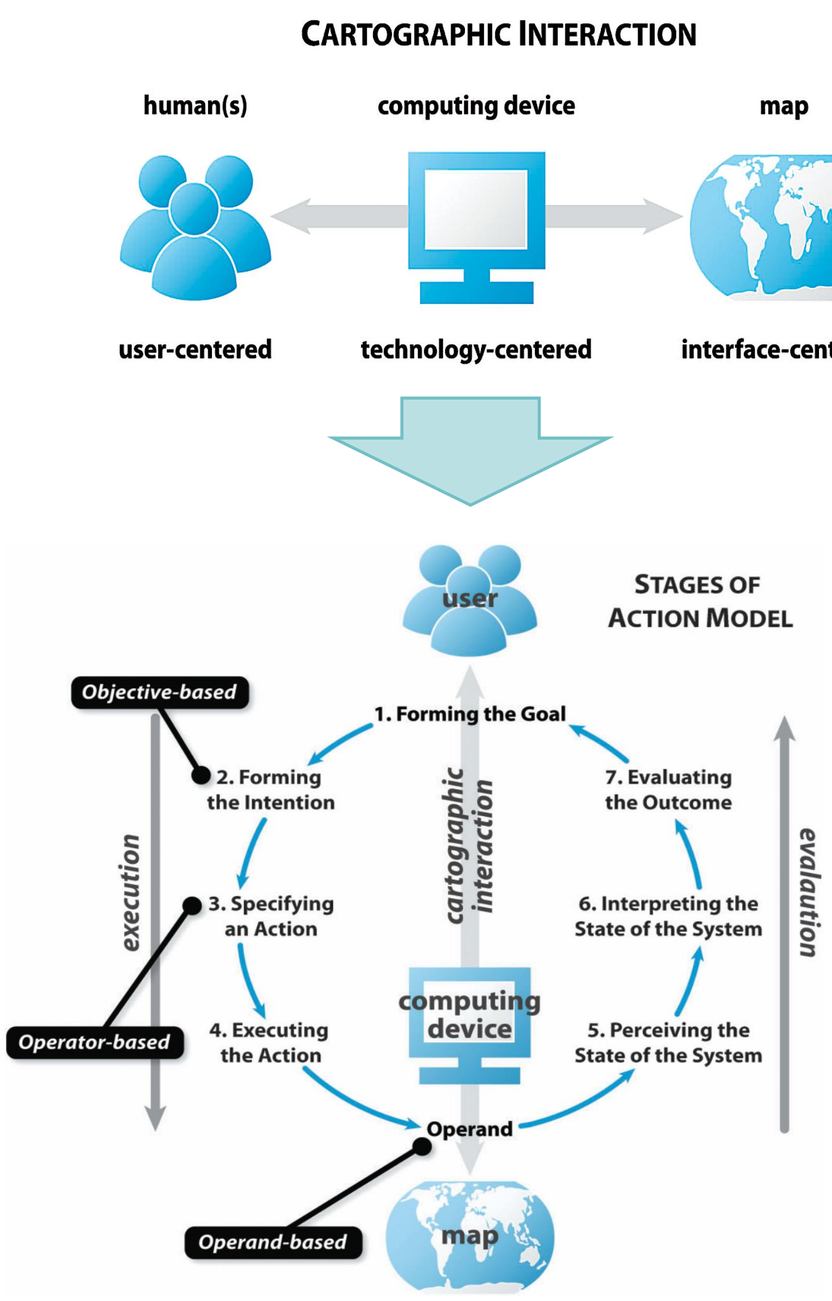

Fig. 2. The shift in understanding of cartographic interaction (Roth, 2012)

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Interaction primitives

Tab.1. Taxonomies of interaction primitives (Roth, 2012)

Objective-based taxonomies		
Crampton (2002)	Interactivity Tasks	(1) examine, (2) compare, (3) (re)order/(re)sort, (4) extract/suppress, (5) cause/effect
Operator-based taxonomies		
MacEachren et al. (1999)	Interaction Forms	(1) assignment, (2) brushing, (3) focusing, (4) colourmap manipulation, (5) viewpoint manipulation, (6) sequencing
Operand-based taxonomies		
Ward and Yang (2003)	Interaction Operands and Spaces	(1) screen, (2) data, (3) data structure, (4) attribute, (5) object, (6) visualisation structure

Tab. 2. Suggested taxonomy of interaction primitives for 3D geovisualization

1	**Search**	
1.1	self localization	Where am I?
1.2	presence/absence	Is there a lake?
1.3	counting	How many buildings are there?
2	**Pattern recognition**	
2.1	trend	Is there a global trend in the heights of buildings?
2.2	repetition	Is there any specific pattern in the terrain shape?
3	**Spatial understanding**	
3.1	absolute comparison	Which hill/top is in the highest place?
3.2	relative comparison	Is a trigonometric point "A" higher than trigonometric point "B"?
3.3	comparison with different type of visualization	Which one from terrain profiles is displayed as a 2D graph?
4	**Quantitative estimation**	
4.1	absolute estimation	What is the slope of the road?
4.2	relative estimation (binary)	Do the heights of trees depend on altitude?
4.3	relative estimation (quantitative)	How many times higher is a building "A" than building "B"?
5	**Shape description**	How would you describe the shape of the terrain?
6	**Combined tasks**	Find all the buildings in the terrain and determine which one is the highest one.
7	**Planning**	Determine a specific place where it would be suitable to place a lookout to see all of the landmarks.

Discussion

Interaction primitives represent elegant way for understanding interaction, better working and design in 3D virtual geovisualizations. The human-computer interaction approach strive for measureable and transparent taxonomy, which will serve as a reference framework when developing virtual products (Laha et al., 2015). This demands to establish a brand new taxonomy and follow-up methodology, which can offer specific data about process of interaction and its further parameters. We derived such a taxonomy from existing and promote to use it in virtual cartographic tasks.

References

LAHA, B., et al. A Classification of User Tasks in Visual Analysis of Volume Data. In: *IEEE Scientific Visualization Conference 2015*. Chicago: IEEE, 2015.
ROTH, R. Cartographic Interaction Primitives: Framework and Synthesis. *Cartographic Journal*. 2012, 49(4), 376-395.