Geo-Visual Analytics: Requirements form a user perspective

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Introduction

The scientific investigation of real-world phenomena in space and time has become a data-intensive science in the last decade; especially at interdisciplinary research laboratories like the German Research Centre for GeoSciences (short GFZ). Terrestrial, marine and space-based high resolution sensor systems as well as complex simulation models create massive data. For instance the TerraSAR-X and the following TanDEM-X Satellite mission lauchend in June 2007 have created 1.5 Petabyte data since now which would, if stored at CDs, form a stack of more than 430 m and thus, top the Eiffel Tower. New insights into phenomena in space and time are often only achieved by deriving a good understanding of relationships hidden in those vast volumes of data.

Visual Analytics, in our particular case, GeoVisual Analytics, wants to cope with this challenge by integrating methods from knowledge discovery and interactive visualization in an integrated framework to facilitate geoscientists and decision makers in their knowledge creation and sense making process. GeoVisual Analytics aims at utilising the strenght of a) knowledge discovery which allows for fast analysis of spatio-temporal data and pattern recognition, b) interactive geovisualization which represents data in a way that affords seeing and interacting and enable thought processes to translate from data to information, and c) the human's knowledge, assessment and reasoning potential that helps to refine and organize information more appropriately in an analytic discourse.

In close collaboration with scientists from various fields of geo-science at the GFZ we learned important lessons in many meetings and discussions, and received important requirements of domain experts for Geo-VA. We believe that feedback from potential users of Geo-VA tools is crucial to evolve Geo-VA into a mature technology in the geo-scientific community. In our presentation we will point out the following lessons learned and requirements and demonstrate examples from GFZ.

Lessons learned and requirements

a) Geo-VA needs to be an integrated part in the entire scientific discovery process

The geo-scientific questions investigated at the GFZ are usually deep and challenging. They deal for instance with processes causing earthquakes or sea level change, the investigation of geogenetic climate factors, or the development of methods for geo-engineering, e.g. for tunneling by guiding huge drilling machines according to real-time measures in the solid rock. Our experience is that geo-scientific questions are far to challenging to get completely supported by Geo-VA. However, Geo-VA can support geo-scientists to get insight into certain aspects of the questions. Geo-scientists are usually approaching their research topics through a sequence of reasoning actions which we call the scientific discovery process. VA can play a crucial role in this process. We made the experience that domain experts are willing to use VA as a scientific tool to advance their scientific discovery process, but VA that is not closely related to the domain requirements and that does not address requirements of the much bigger scientific discovery process

will have difficulties to become a mature technology in many fields of geo-sciences. The lesson we learned is that Geo-VA has to be directed to the scientific discovery process at a whole. It needs to guide the expert to the next insight or offering the next step in the scientific discovery process.

b) Geo-VA needs a sound scientific basis

Domain experts in many geo-scientific fields are usually trying to find a formalized model to explain the behavior of a real-world phenomenon by assembling proper methods. The aim of this assembly pipeline is to increase the experts confidence that the data, either measured by sensors, or calculated by simulations, has certain properties. At a certain point in the assembly pipeline domain experts are often unaware of alternative interpretations of the data. This is a great opportunity for visual analytics since the narrow focus on formulating and testing certain assumption may cause misleading interpretations of real-world phenomena or of calculated simulations. We also mad the experience, that deep scepticism by the domain experts exist about alternative interpretations of the data obtained by VA tools alone. To cope with these challenges Geo-VA needs to study the limitations of the assembly pipelines, and to develop a sound scientific basis on the limitations of geo-analytical methods and geo-visualization, on the integration of geo-visualization and geoscientific concepts, and on the enhancement of the scientific discovery process by comparison data against reference situations.

c) Geo-VA needs a theoretical framework

At present no clear understanding of VA and Geo-VA exists. Answers to important questions like What is VA/Geo-VA? or What is the subject of VA/ Geo-VA? has been predominantly reported as the combination of analytical methods and visualization. Starting from there, does Geo-VA needs to be integrated in a bigger analytical process which we call scientific discovery process? Our experiences with domain experts indicate that it is fundamental to include the analytical process and domain specific concepts into Geo-VA, otherwise Geo-VA will not become an efficient tool and so no mature technology in geo-science. The integration of analytical process and domain specific concepts evokes questions like Which methods and concepts are needed to be integrated into Geo-VA? And How to detect and define the shortcomings of existing analytical methods and pipeline which could be overcome by Geo-VA? A further question will be which parts of Geo-VA concepts and tools can be generic and which have to be domain specific? Finally we have to define measures to evaluate Geo-VA and find answers to the questions: What do efficiency and effectiveness mean in a scientific discovery process in which Geo-VA should guide the domain expert to the next insight needed to gain an understanding of a deep and challenging scientific question? How to quantify the effectiveness or efficiency to understand a deep and challenging phenomena more easily? Geo-VA research should focus on developing criteria to specify domain requirements that needs at least to be fulfilled for successful adoption.

We will illustrate the requirements with examples from GFZ.