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Visualization of Uncertainties for Geo-Scientific Data

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We present visualization techniques for integrating information on data errors and uncertainties into the geo-scientific visualization process. These errors and uncertainties can emerge during data collection, simulation, data transformation and processing and even during data visualization. Geo-scientists are more and more interested in the regions and magnitude of the uncertainty present in their data. This information - widely ignored in today's visualization systems - could increase the confidence into the decisions of geo-scientists.

The field of uncertainty visualization is quite young, but there is ongoing activity to develop methods to present indications about data reliability to users. The main goal of these methods is to present the data in such a way that the user is made aware of the type, location and magnitude of the uncertainties in his data. How this goal is met differs between particular methods. There are two main directions: To use the uncertainty information directly during the rendering process to alter the appearance of the presented data in unreliable regions. Other approaches use the information to add special uncertainty illustrations which overlay the actual data presentation.

We developed methods to specifically show uncertainty in geo-scientific data collected through seismic surveys. Typical visualization methods for seismic data include direct volume rendering of the seismic volume or rendering of interpreted surface data such as faults and horizons. We show how uncertainty information can be integrated into both visualization primitives. Furthermore we try to convey a sense of the nature of the presented uncertainty.

For the direct visualization of uncertainties in a seismic volume we employ different techniques to manipulate the color mapping according to the amount of uncertainty present in the data. Such techniques include desaturation as well as inverting or changing the transparency. Other techniques, such as volume distortion and blurring in affected areas try to directly show the effects of positional uncertainty of the data samples in the volume. The distortion method allows to present different variations of the same data set to the viewer. Combining these approaches with animation allows to gradually add and remove the effects of the methods to the actual data visualization. We employ similar direct visualization methods to the interpreted surface data such as local surface deformation or the alteration of their appearance. We also use indirect visualization techniques like superimposing glyphs or a volume on the actual data visualization. Using glyphs the uncertainty information is encoded through the change of attributes of discretely placed geometries, for example the length or color of lines. The volume surface approach tries to emphasize the reliability of surface regions through the thickness of the surface. Our system also allows to combine different techniques to complement each other and to enable users to get a better overall impression of the surface and volume uncertainties.