VISUAL ASSISTANCE TOOLS FOR INTERACTIVE VISUALIZATION OF REMOTE SENSING DATA

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1. INTRODUCTION

Interactive visualization of remote sensing data gives the user much control over the visualization result. In the ideal case, the complete processing chain that is necessary to map sensor data to geometry or color can be manipulated interactively. Additionally, interactive data fusion allows weighting and blending of data sets from different modalities.

For example, one view might combine a Digital Elevation Model (DEM), a Synthetic Aperture Radar (SAR) amplitude image, a multispectral image, and temperature data. For the DEM, a hole-filling or postprocessing filter might be applied. For the SAR image, despeckling and dynamic range reduction methods can be chosen and adjusted. For the multispectral image, specific bands or band combinations can be chosen. The temperature data can be mapped to various color scales. Finally, blending weights can be adjusted to overlay SAR, multispectral, and temperature data.

In this scenario, the user has a lot of interactive control and can fine-tune all methods and parameters interactively to achieve the optimal result for the given task. However, this flexibility comes at a price: finding the optimal set of methods and parameters can be difficult and time consuming.

Various user interface concepts have been proposed to help the user manage the complexity of interactive visualization. In this paper, we show how two of these concepts, *lenses* and *detectors*, can be applied to interactive visualization of multimodal remote sensing data. We integrate both concepts into our visualization framework and present results.

2. FRAMEWORK

We built a framework for interactive visualization of multimodal remote sensing data [1]. The framework uses graphics processing units (GPUs) to a large extent to meet the demand for computational power that this task requires. In this section, we will briefly review aspects of the framework that are important for the implementation of lenses and detectors.

From a visualization point of view, there are two categories of sensor data. *Geometry* data is mapped to vertices by the visualization system. This kind of data is usually provided as DEMs. *Texture* data is sensor data that is in some way mapped to color or transparency. This category includes orthophotos, SAR images, multispectral images, and any kind of data that can be mapped to color scales.

The base data structure for all data sets is a unified quadtree variant, based on the WGS84 map. Both geometry and texture data sets are mapped to this hierarchy. The framework lets the user interactively define the processing chains that map the sensor data to geometry and color. This processing is performed on all quads of the hierarchy that are necessary to render the current frame. As a consequence, user interfaces that help the user with the task of choosing visualization methods and parameters need to work on the same data representation level, i.e. sensor data stored in a quadtree hierarchy.

3. LENSES

The concept of the lens allows two sets of visualization parameters to be active at the same time: one global set, and one local set that only applies to the region of the lens. This concept allows to compare two different parameter sets directly, thus giving additional insight into the data and simplifying the choice of a particular parameter set.

The lens metaphor was introduced by Bier et. al. [2], extended to 3D volumetric lenses by Viega et. al. [3] and applied to remote sensing data by Borst et. al. [4].

The implementation of lenses is specific to the application. For a 3D lens as proposed by Borst et. al., it is necessary to know the geometry of the scene at the time the lens is applied. The same is true for 2D looking glass lenses. Both kinds of lenses need to determine the part of the geometry for which they are relevant. In contrast, our framework does not know the geometry before the lens is applied, because the geometry depends on the visualization parameters defined by the lens. For example, a lens might define processing parameters for a DEM data set that differ from the global parameters.

For this reason, we use a lens that represents a 2D circular area on the WGS84 geoid. For each quad that is processed for display on screen, it can be decided if it is inside the lens, outside the lens, or if it intersects the lens. This determines if it must be processed with the lens parameters, the global parameters, or both. In the latter case, an additional postprocessing step is applied that combines the two resulting quads into a single quad by determining for each sample whether it lies inside or outside the lens. This allows to generate consistent and crack-free geometry even at the border of the lens.

4. DETECTORS

A detector allows the visualization system to find interesting features in the sensor data in real time. The system can then display visual hints, thereby guiding and assisting the user in exposing the important detail of the data.

Detectors need to work on the sensor data and not on the resulting geometry or color information, because the geometry and color depend on the processing results and will vary between consecutive rendered frames.

Feature detection in sensor data is a very large field, and many methods for specific tasks exist. Additionally, much work exists on implementing feature detection methods on GPUs to allow interactive use.

Detectors that guide users in interactive visualization tasks may compute additional information about the detected feature, and encode that in a graphical hint displayed on screen, so that the user not only gets an overview of the interesting features, but also their properties. Selecting a hint then allows the user to examine a feature in detail. An example for such a feature detector is our point target detector for SAR images [5].

In the context of interactive visualization of multimodal remote sensing data, different feature detectors for each modality may exist, concentrating on different kinds of features. Because the detectors work on quads from a quadtree hierarchy, they need to take the different resolutions of different quadtree levels into account. If a feature is found, it may be necessary to access the sensor data at its original resolution for further examination.

Each feature initially only has a 2D location on the geoid surface, because the full 3D geometry is not yet known. The visualization system must make sure that visual hints are displayed at the correct position once the full geometry is computed.

5. RESULTS

We implemented both lenses and detectors in our GPU-based framework. The example in Fig. 1 shows two DEMs, a SAR image and an RGB image in the same view. The first DEM is from the NASA Blue Marble Next Generation (BMNG) data set. The second DEM is the augmented SRTM data provided by CIAT. The SAR image was taken by the TerraSAR-X satellite. The RGB image is from the BMNG data set.

The lens area shows exaggerated elevation data from the CIAT data set, while the rest of the image shows elevation data from the BMNG data set. Nevertheless, the framework is able to show a consistent, crack-free surface. In the lens area, the BMNG RGB data appears brighter, and the SAR image shows more contrast than outside the lens. Additionally, it has a greater blending weight inside the lens so that it dominates the RGB image.

Since few quads need processing with both global and lens parameters, the performance impact is small.

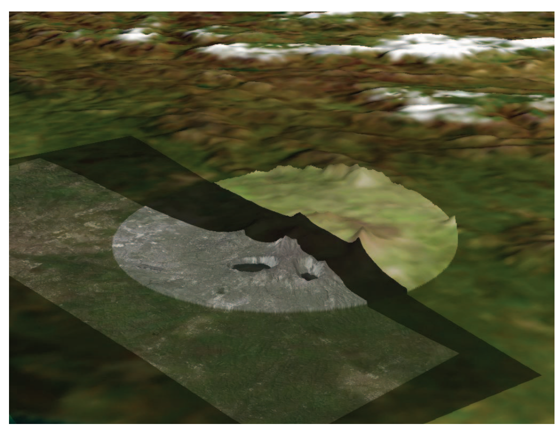

Fig. 1. Example for lens functionality in the visualization framework.

6. CONCLUSION

Interactive visualization systems offer great flexibility to the user, but with this flexibility comes complexity. This is especially true in the context of visualization of multimodal remote sensing data, since each modality provides its own set of methods and parameters for mapping sensor data to geometry and color, and, additionally, flexible data fusion methods need to be adjusted.

To guide and assist the user with the choice of methods and parameters, and to provide additional insight into the data, user interface concepts like lenses and detectors can be used. However, these concepts have to be adapted for this purpose. In contrast to other application scenarios, the interactive visualization of remote sensing data requires them to operate on a low-level, hierarchical sensor data representation, since the geometry and appearance of the visualized data is not known a priori.

We have integrated two such user interface concepts into our GPU-based visualization framework to demonstrate their applicability and usefulness.

7. ACKNOWLEDGEMENTS

This project is partially funded by grant KO-2960-3/1 from the German Research Foundation (DFG). The NASA Blue Marble Next Generation data sets were produced by NASA Earth Observatory (NASA Goddard Space Flight Center). The SRTM data set is provided by the International Centre for Tropical Agriculture (CIAT) [6]. TerraSAR-X data sets © Infoterra GmbH.

8. REFERENCES

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