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Poster: An Interactive, Visual Composite Tuner for Multi-layer Spatial Data Sets

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Abstract

Packing high-dimensional data into comprehensible visualizations is difficult. A number of techniques exist to composite multiple layers of data. However, these techniques require a lot of parameter manipulation to achieve an image in which each layer can be segmented from the others over the entire surface. We propose an interactive, multi-view system for creating multi-layer composites and setting the parameters of the data mapping in real-time. We developed efficient, hardware-accelerated implementations of two multi-layer techniques, Data-Driven Spots and Oriented Slivers. Our prototype application allows for interactive parameter tuning of custom techniques written in HLSL and visual exploration of the data using these parameters, including the manipulation of piecewise transfer functions between layer intensity and opacity.

CR Categories: I.3.6 [Computer Graphics]: Methodology and Techniques—Interaction Techniques

Keywords: multi-layer visualization, transfer function, GPU

1 Introduction

Multi-layer visualizations often enable (require) tuning numerous parameters in order to produce a quality visualization. We applied such techniques to Landsat 7 imagery [Landsat Project Science Office 2009]. We needed a system that would enable interactive exploration and be usable by GIS analysts, who are not generally experts in visualization techniques. Thus we explored both real-time rendering techniques for multi-layer visualizations and graphical user interfaces (GUIs) that might prove usable for people who are familiar with the data but not customary GUIs for such problems.

Landsat images are multi-spectral, with three bands roughly corresponding to visible light and four infrared bands. An obvious visualization method becomes to map the first three images to the appropriate color channels in rendering. This leaves no easy channels for the remaining bands; however, all bands have uses in terrain (soil, vegetation, urban sprawl) analysis. False color scheme and ratio images may elucidate certain features, but at the expense of others. Our long-term goal is to devise visualizations that show the full range of features. To do this, we needed to craft methods to control multi-layer visualizations for non-experts in visualization.

2 Related Work

Oriented slivers [Weigle et al. 2000] were short lines grouped by orientation and illuminated according to the field value. Users could understand interactions between layers because separating orientations by 15° perceptually grouped a high number of layers with

out occupying color channels. Data-driven spots (DDS) [Bokinsky 2003] sampled multiple scalar fields with Gaussian kernels, separating fields by hue, kernel size, and animation (velocity). Up to eight layers, aided by jittering the samples, could be segmented. Double-layer visualization techniques apply to hyper-spectral satellite imagery [Cai 2009]. One layer used pie charts to show pixel composition, taking advantage of the non-negative range and that such imagery sums to unity. This enabled better performance in pixel composition than traditional approaches (grayscale and color maps) and improved understanding of global distribution.

Transfer functions vary intensity and opacity in volume rendering, but designing good functions is not easy. It requires domain expertise, including the data acquisition process. Multi-dimensional transfer functions for medical data can be based on data value, gradient magnitude, and a second directional derivative [Kniss et al. 2001]. They also designed direct manipulation widgets to specify such transfer functions, building a frame with the current data slice in which to get interactive feedback on the effect of the transfer function on the value and gradient dimensions. This approach, however, required per-voxel storage of all function variables, limiting its application to large data sets. *Style transfer functions* use different glyphs at control points of the transfer function to indicate the effect on the rendering [Bruckner and Gröller 2007]. These glyphs may represent any parameters of the rendering rather than the domain and range of the transfer function.

3 Multi-layer Image Visualization

We took two approaches to arrive at our interactive tool for exploring the multi-layer Landsat imagery: (a) real-time rendering that would respond whenever the user altered parameters through (b) the GUI designed for non-experts in computer graphics.

3.1 GPU Visualization Algorithms

While brush strokes [Laidlaw et al. 1998] offered the number of properties we needed, we felt this technique was less likely to be accepted by our end users, who are accustomed to the realistic geometric appearance of the satellite imagery. Thus we implemented DDS [Bokinsky 2003] and oriented slivers [Weigle et al. 2000].

Data-Driven Spots are rendered in a pixel shader, run once in parallel for each pixel of the layer, accelerated via graphics hardware. Each pixel has a texture coordinate, or relative position in the layer. From this coordinate we identify the grid cell of the pixel, based on a user specified number of cell divisions. Using a local texture coordinate relative to this grid cell, we sample four 2D Gaussian functions centered at the corners of the cell. We sample four kernels at the corners instead of one at the center so we can jitter these centers to create a random looking pattern (Figure 1, right). The amount of jitter is user-defined and the offset direction is random for each spot on the grid.

Oriented Slivers are handled using a very similar pixel shader. Instead of sampling 2D Gaussian at each corner, we sample a set pattern image, with a user-specified rotation, width, and height. These parameters are uniform across all patterns within the grid, just like the parameters of the Gaussian kernels in the description of DDS. Furthermore, the patterns at each corner are jittered using the same process defined above.

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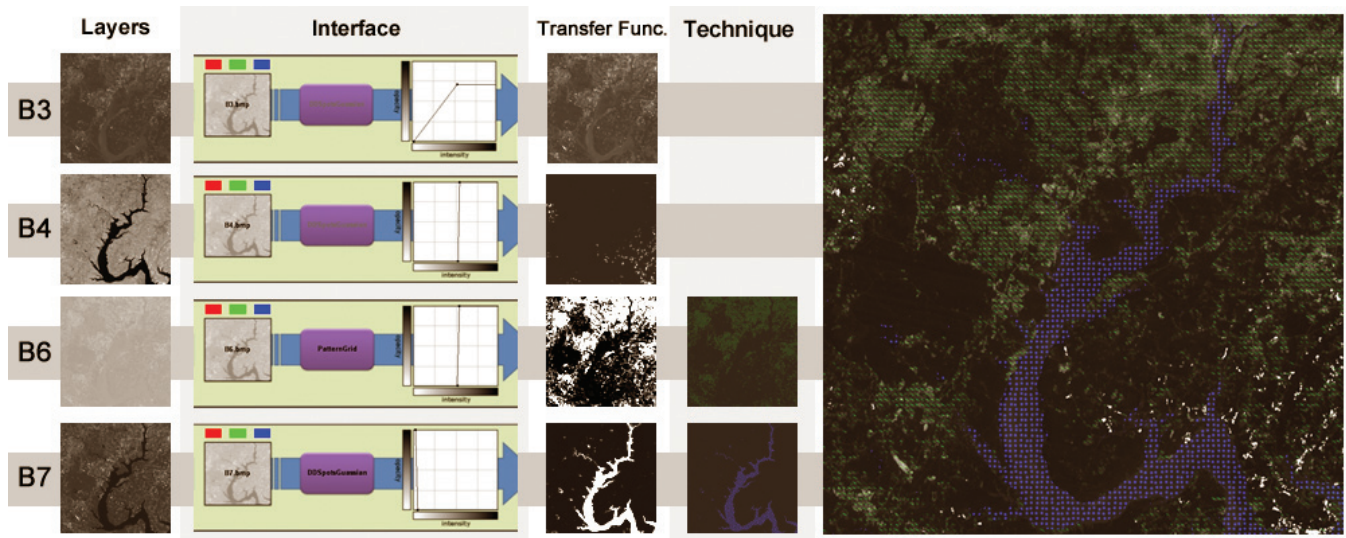


Figure 1: Snippets from our application’s control view and main view. Right: the final composite image for bands 3, 4, 6 and 7 of a Landsat 7 image. Left: Four flow charts for these layers, showing the interface options, transfer functions, and algorithms that produce the composite.

3.2 Graphical User Interface

Each layer has a separate set of controls, stacked in a scrollable window. The first set of controls lie on a flow chart that illustrates the pipeline of the application for each layer (Figure 1, under ‘Interface’). This flow chart shows (from left to right) the layer name, the technique (per-pixel operation), and a transfer function. These images allow the user to manipulate a layer, respectively: toggle layer being displayed, toggle the technique being applied (off implies a linear function), and manipulation of the transfer function.

The transfer function maps input intensity to output opacity using a piecewise linear function defined by control points. Users may add control points (left click), delete them (right click), snap them vertically (left click under/over a control point), or grab and drag a control point (left click on the point). With our real-time rendering, effects may be seen immediately in the main view. Each technique has a number of parameters associated with it, manipulated dynamically via sliders (not shown) below the flow chart for each layer.

Figure 1 shows a combination of layers and the transfer functions that produce the effect. Band 3 (good for roads and bare soil) can be seen as a light background image. Band 4 (soil moisture) is represented through only its more intense values (transfer function of a vertical line). Band 6 (thermal radiation) is shown using a green Oriented Slivers pattern and Band 7 (vegetation moisture) is inverted to highlight the rivers using blue DDS. This composite shows how urban structures and rivers are affecting soil moisture.

4 Future Work

We have demonstrated two techniques, but additional techniques can run within our application. New techniques in our framework must operate on each layer individually and sum the results. Layer combinations, such as the difference between two layers, can be used as input into the application, but a technique cannot sample from more than one input image. Many techniques operate within this model, but expanding it would enable us to incorporate additional techniques and explore interactive layer combinations.

Though radiologists have learned to manipulate them, we find the transfer functions too complicated for our GIS users. We plan to introduce constraints that enforce good visualization design concepts

and reduce the parameter space. For example, color selection for one layer may alter colors for other layers; a palette for all layers could be used. Similarly, one orientation of slivers limits available orientations for other layers. Within a layer, a light intensity might not work for a narrow sliver. We plan to explore multi-dimensional transfer functions for styles.

We have not tested the GUI and techniques with end users, a critical element in future work. Our discoveries led us to consider application to hyper-spectral imagery, which are densely sampled and high-frequency data. Sampled visualizations do not lend themselves well to such data, but we believe such techniques, applied to specific data types, will enhance multiple layers of hyper-spectral imagery while maintaining the familiar geometric representation that GIS analysts like. We believe that analysts’ capabilities will be improved by enabling more layers than the current visualizations.

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