Selective Saturation and Brightness for Visualizing Time Varying Volume Data

Shengzhou Luo and John Dingliana
luos@tcd.ie | john.dingliana@tcd.ie

gv2 graphics • vision • visualisation
Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin
ARTIVVIS

Introduction

Motivations

- Time-varying volume data is used in many areas of science and engineering.
- Visualizations of such data are not easy for users to visually process due to the amount of information that can be presented simultaneously .

Objectives

- A novel visualization approach which modulates focus, emphasizing important information, by adjusting saturation and brightness of voxels based on an importance measure derived from temporal multivariate information.
- Acquisition of the volatility measure of each voxel, by conducting a voxel-wise analysis of a number of consecutive frames.

Method

- An intuitive approach for using color mappings in HSB space to effectively represent multivariate time-variant data.

  1- Opacity represents the main variable and the saturation represents the volatility of the main variable.

  2- Brightness can be used to represent other information such as an additional variable from a multivariate or multi-dimensional data set.

  3- For a multivariate data set with two variables X, Y, we use variable X of voxels for the alpha channel and modulate the saliency of voxels by adjusting saturation and brightness based on the volatility of variable X and the values of variable Y respectively.

  The **volatility** is measured by temporal standard deviation std(i), which is the standard deviation of the i-th voxel in the recent n consecutive frames, where n is a user specified number.

  The hue, saturation, brightness and alpha of the i-th voxel (an element in a volume data set) in HSB color space are defined as follows:

$$\mathrm{Hue}(i) = C(i)$$
$$\mathrm{Saturation}(i) = \mathrm{Clip}(a \times \mathrm{std}(i))$$
$$\mathrm{Brightness}(i) = 1-\mathrm{Clip}(b \times Y(i))$$
$$\mathrm{Alpha}(i) = X(i)$$

where std(i) is the volatility and C(i) can be either a user-specified constant hue or mapped to a variable such as X(i). Clip is a function that clips the value to the range [0, 1]. a and b are scale factors for saturation and brightness respectively, which are determined by the user based on the distribution of variables X and Y in the data set. Variables X(i) and Y(i) are normalized to the range [0, 1].

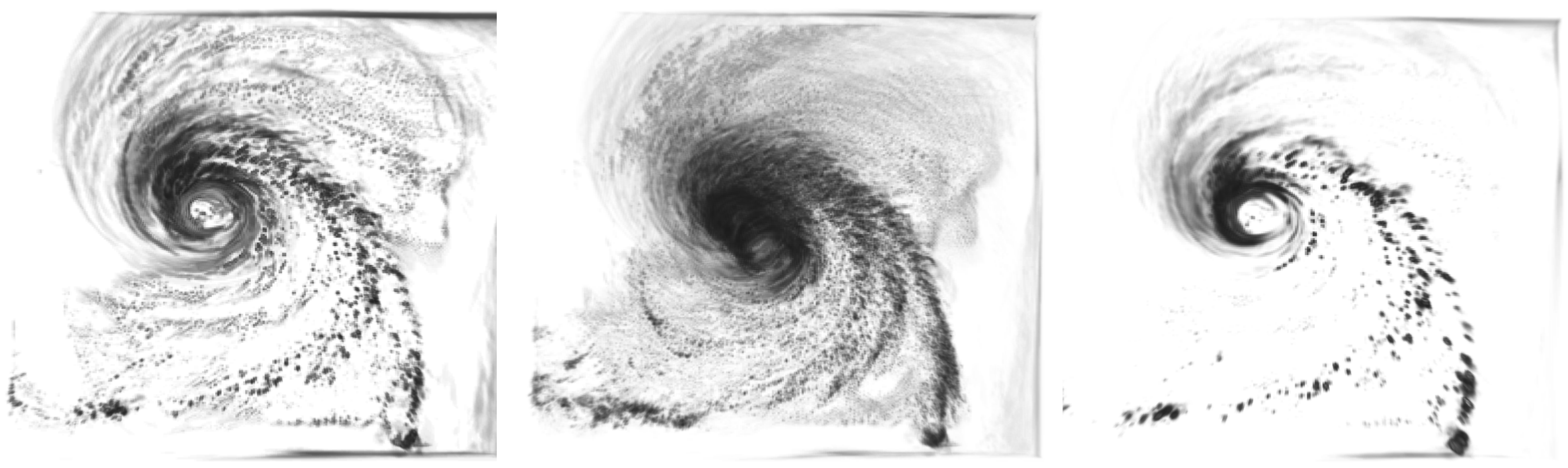

Figure 1. The three inputs used in our tests. From left to right, cloud moisture mixing ratio (kg water/kg dry air), volatility of cloud moisture mixing ratio and total precipitation mixing ratio (sum of mixing ratios of graupel, rain and snow) at frame 35 (black for low intensity)

Conclusions

- Our main contribution is a mechanism for exploiting saturation and brightness to modulate focus in time-variant volume visualization using an importance measure that is based on volatility.
- We demonstrate how additional variables in a multivariate data set could be communicated simultaneously through the brightness channel.
- **Future work:** we plan to conduct perceptual experiments to quantitatively evaluate the mechanism and determine the optimal parameters for the approach.

Results

- Test Data set: Time-varying dataset of Hurricane Isabel, WestAtlantic region in Sept/2003. From the National Center for Atmospheric Research as provided for the IEEE Visualization Contest 2004.
- Data set size: 500 (longitude) x 500 (latitude) x 100 (height) x 48 (time). One time-step is one hour in the simulation.
- Ground in the hurricane data set is a height field of the surface topography, rendered with relief mapping and presented as background in the visualization results.
- The temporal standard deviation is calculated using the recent 10 frames. In Figure 2, 3 (right) and 4, the strong red color near the hurricane eye indicates where the hurricane was in previous several frames and the clouds with more precipitation are darker in the images.

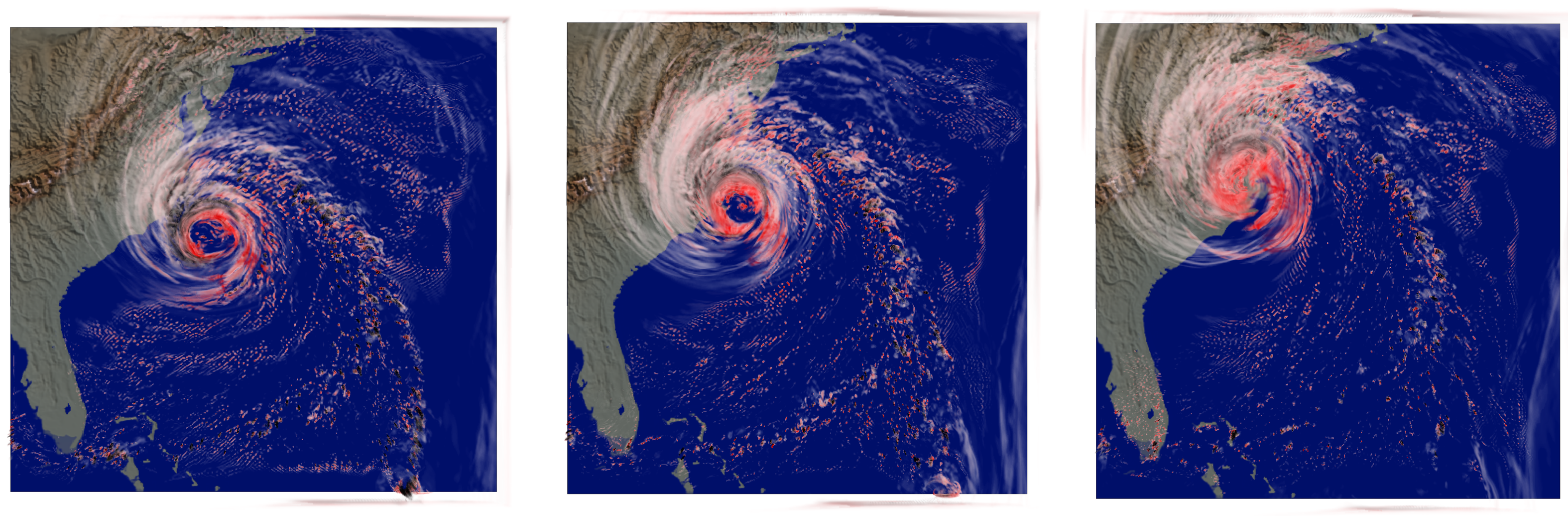

Figure 2. Rendering of cloud with precipitation (darker for more precipitation) of Frame 35, 40 and 45. The volatility is utilized for adjusting saturation and the precipitation is used for adjusting brightness.

- We applied the Graph-based Visual Salliency algorithm [HKP06] to estimate visual saliency maps resulting from visualisations of frame 35 using our approach and a standard transfer function (Figure 3). As can be seen, the saliency map correspoding to our visualisation approach (right column) indicates more concentrated focus on the hurricane eye compared the the saliency map which uses a standard transfer function.

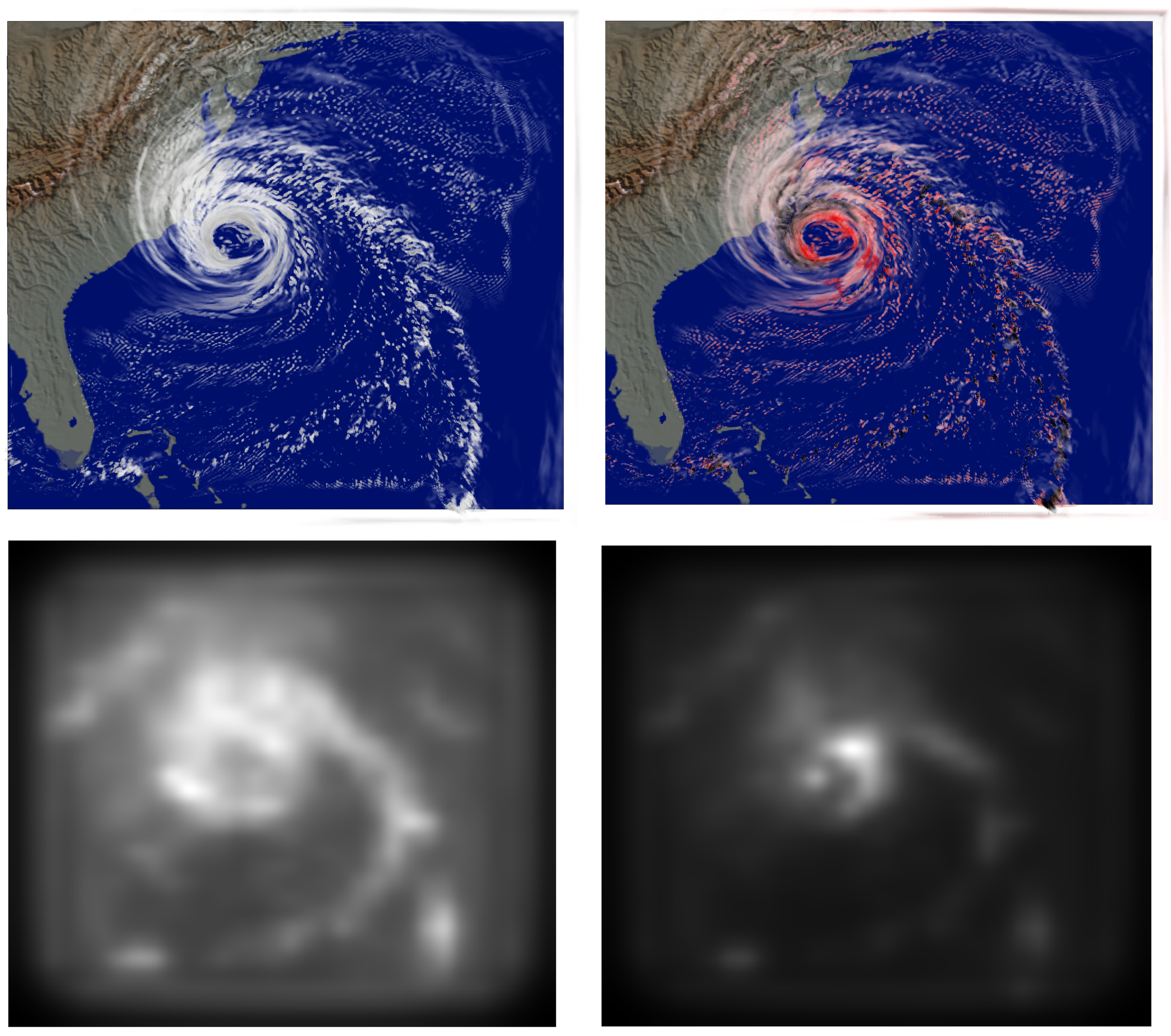

Figure 3. Top: Frame 35 of data set rendered using standard transfer function (left) and our approach (right) Bottom: Graph-Based Visual Saliency maps [HKP06] of corresponding visualisation

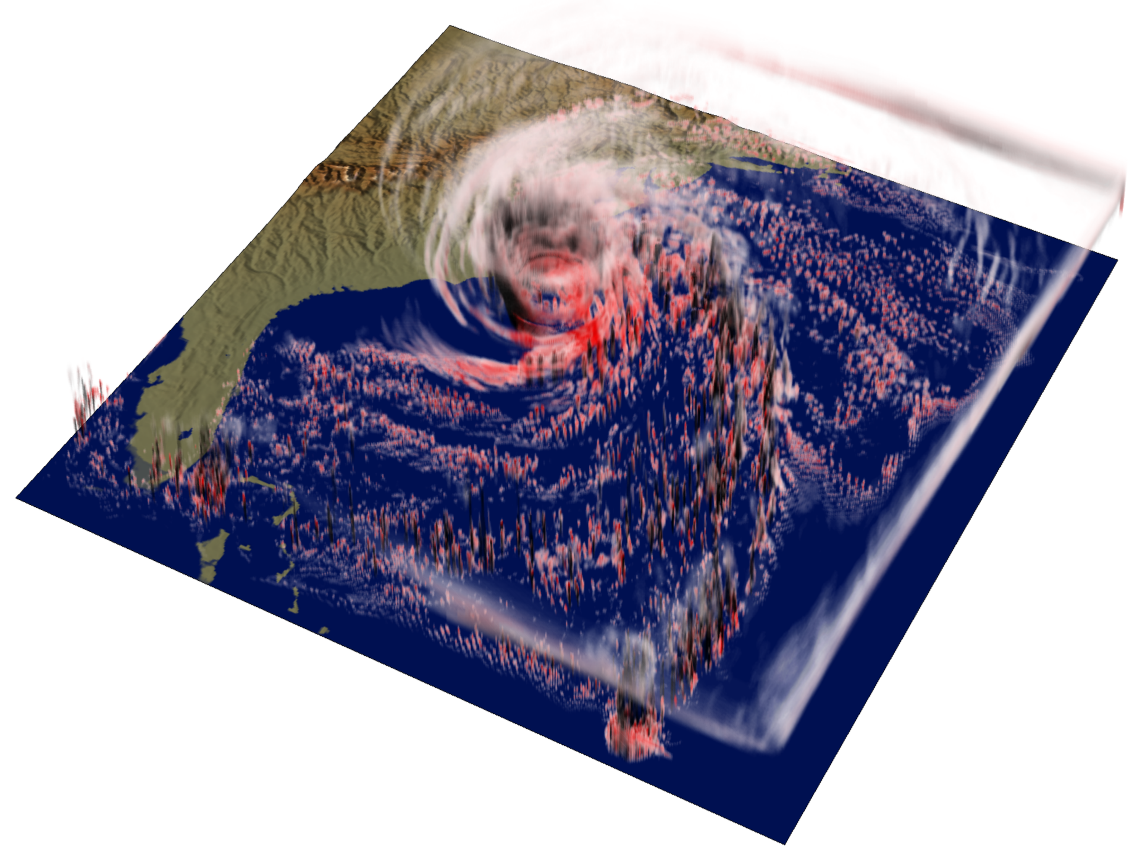

Figure 4. Frame 35 rendered using our technique from a side view.

References: [HKP06] Harel J., Koch C., Perona P.:Graph-Based Visual Saliency.
In Proceedings of Neural Information Processing Systems (NIPS) (2006), pp. 545–552.

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