Streamline Splatting

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We propose a new technique called *streamline splatting* to visualize 3D vector fields. The core idea is to first generate effective streamlines and then apply the splatting method of volume rendering based on the generated streamlines. We apply this technique to a couple of examples of 3D flows. It can render dense but comprehendible images quite efficiently and has a promising potential to achieve interactive visualization.

The first task of our approach is the generation of streamline curves. To do this, we use a fourth order Runge-Kutta ODE solver that steps along a streamline, starting from a randomly chosen point in the data space. At each step, the start and end positions and the respective tangent vectors are taken and projected onto the buffer. This is illustrated in Figure 1, where a curve segment from point $\mathbf{p}_0$ to $\mathbf{p}_1$ is projected onto the viewing plane and becomes a projected curve.

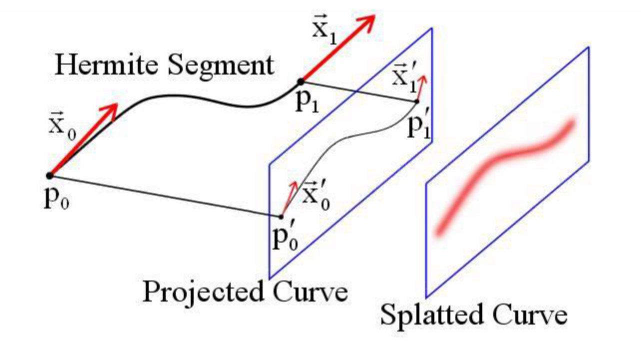

Figure 1: Streamline curve segment projection and splatting.

In the second phase, the project curve is transformed into a splatted curve with soft shade. The streamline splat represents a wide brush stroke. The space it covers is given the color and geometric properties of the original streamline. The footprint structure permits the blending of streamlines, allowing important features in the visualization to contribute instead of being occluded as more streamlines are drawn.

Curve projection uses Hermite interpolation to trace along the streamline with a Gaussian function. A 2D Gaussian function is used, but variation in intensity and radius of the Gaussian with respect to distance improves the clarity of depth in the visualization. The user therefore can distinguish streamlines based on distance, and further details are given less weight in the image.

The use of footprints and blending to render the streamlines of a vector field can often lead to a dangerous situation: losing the detail when too many streamlines cross a small region of the buffer. This can become as severe as making a portion of the rendered image white from over accumulation. A few methods are studied to prevent this from happening. One method divides the data space into smaller regions, each one of these is then associated with its own counter. Each time a streamline passes through a region, the counter is incremented. Furthermore, if the counter is above a certain amount, the streamline will not be splatted onto the buffer; instead, skipping along the streamline until either reaching the maximum streamline length or a region is found that is not over populated. The other method determines what position the line segment would take on the buffer, and then averages the total color over a small region surrounding that point. If the average is above a certain amount, i.e. too close to being white, then the streamline will not be splatted there; instead, moving on as in the previous technique.

Streamline splatting is able to offer good visualization in terms of a dense representation of the vector field, thus providing a much larger amount of information than using traditional methods for the visualization of 3D vector fields. Figure 2 shows an image a flow dataset of thunderstorm rendered using the streamline splatting method. The colors are coded according to the velocity magnitude and the black regions in the image are continents.

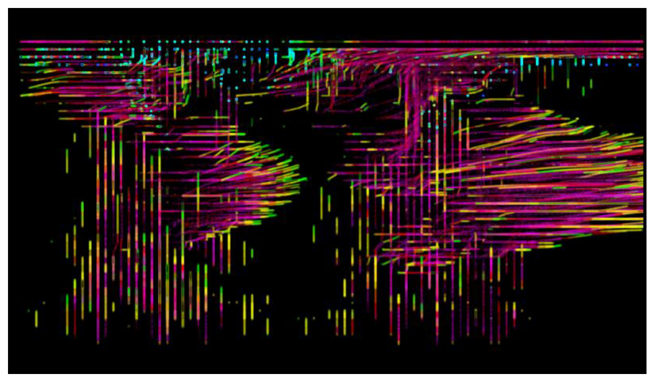

Figure 2: Visualization of a storm flow using streamline splatting.

Future work would be to improve the rendering speed in order to reduce the rendering time sufficiently for interactive visualization. As at the moment, streamline splatting is not able to get the fast rendering times of IBFV methods [1-3]. The current overall performance varies from a fraction of a second to a few seconds, depending on parameters. With further improvement, this technique is promising to achieve interactive visualization.

References

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