Interactive 3D Fluid Jet Painting

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1 Summary

We present an interactive system which allows users to create abstract paintings in the style of Jackson Pollock using three dimensional viscous fluid jets. Pollock's paintings were created by using streams of household paint to make guided, semi-random patterns on his canvas. Our fluid jet model consists of two coupled simulations: a Navier-Stokes solver for an axis-symmetric fluid column and a linked-mass system for tracking the three dimensional motion of the jet's axis line. The paint trails left by the jets are represented using implicit surfaces. Our system also includes an algorithm for generating the splatter patterns created by the impacts of a high-speed fluid drops. We allow users to analyze the fractal properties of the images they create, comparing them to those known to exist in Pollock's own paintings.

2 Introduction and Vision

In the late 1940s, the American painter Jackson Pollock developed a style of painting later deemed Abstract Expressionism. He rolled a large canvas across the floor of his barn onto which he dripped, drizzled and poured household paint. His technique generated a sensation among critics accustomed to traditional brush strokes.

With this seemingly simple painting technique, Pollock managed to create paintings with widely differing visual styles. Common to all of these paintings, however, is Pollock's unique usage of fluid trails of varying widths. The formulation of these trails depends on the interplay between the artist's stroke motion and the dynamics of thin, viscous fluids. In order to simulate this interaction, it is critical to have an interface and real-time fluid model that considers all influencing factors; velocity, gravity, viscosity and surface tension. However, since current 3D fluid jet simulation techniques proved too computationally costly to be used in our real-time application, we developed a stable fluid jet model which couples two different fluid types with reduced dimensions. This allows interactive simulation while still preserving the characteristic fluid behaviors of Pollock's paintings.

Recent mathematical analysis indicates that the fluid jet patterns of Pollock's painting may be related to fractal structure. Pollock's paintings contain self-similar patterns which contribute to the aesthetic quality of the work. This may suggest a correlation between the statistical properties of some abstract art and its aesthetic value. While computers can calculate these properties explicitly, humans may only be able to recognize them subconsciously. As Pollock's painting style matured, the fractal dimension of his images increased. Our system includes an evaluation tool which calculates the fractal dimensions of a user's painting. Users can both create Abstract Expressionist images while analyzing the work's fractal properties. Unlike real-world paintings, our digital system makes users aware of fractal properties interactively, and they can compare the fractal characteristics of each individual's work easily. Our vision is of tools that both engage and inform the artistic process.

Figure 1: Digital Pollock painting.

3 Technical Innovation: Fluid Jet Model

Our fluid jet modeling system has two components: a one dimensional model used to determine the width of the jet, and 3d model that tracks the motion of the jet. Each model influences the other, and together they form a convincing approximation of fluid jet motion which is both stable and computationally inexpensive. The system uses a different mathematical model for each factor. For the transmission of fluid along the fluid jet axis, we use the Navier-Stokes equation in cylindrical coordinates. To model the free motion of a fluid jet 3D, we apply fluid forces to discretized points along the fluid jet axis line. These two models exchange parameters at each time step. When the jet hits a solid surface, an implicit function in 2 dimensions is used to propagate fluid patterns. When the jet hits the canvas it leaves behind a smooth trail of paint, which is calculated and maintained using implicit surfaces.

Our painting system includes a fractal dimension calculator as an indicator of self similar patterns. To measure the fractal dimension we use the well established 'box counting' method. In this algorithm, an image is covered with multiple grids, where each cell is a square with length Li. For each grid, the algorithm finds $Num(Li)$, the number of cells that contain any paint. In our implementation, the largest Li is half the length of the shorter side of the image, and the smallest is 2 pixels. The slope of $(log(Li), log(Num(Li))$ determines the fractal dimension of the image.

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