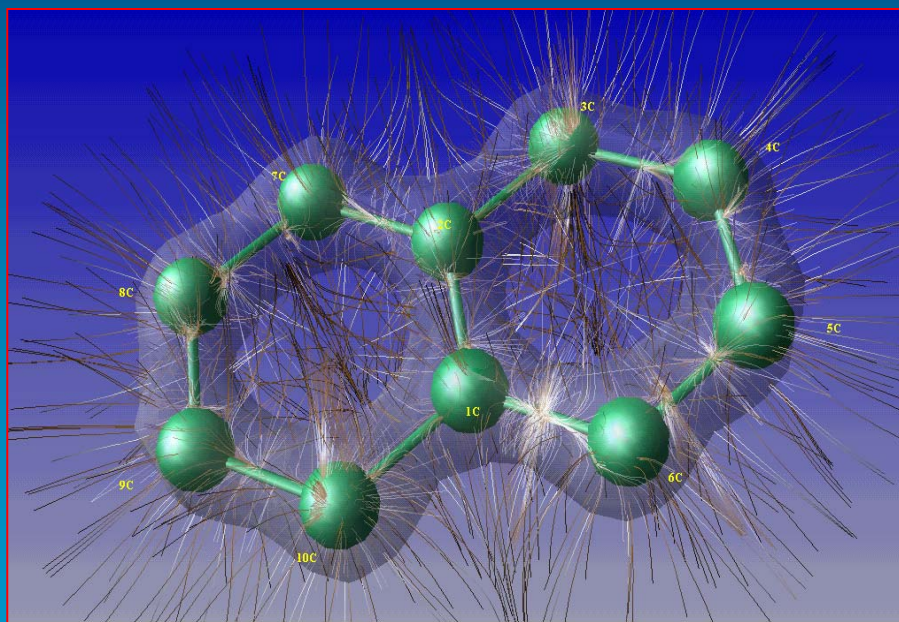




AVS ADVANCED VISUAL SYSTEMS

Animated Illuminated Lines For Flow Visualization



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A paper by Ian Currington



OVERVIEW

- Dynamic Texture Map on 3D Polyines representing field streamlines
- For Continuous Fluid Dynamic fields
- Combining Streamlines and Particle Advection
- ie One single hybrid technique
- Good for large vector flow datasets
- Exploit graphics hardware commonly used for games.
- Based on OpenGL API



INTRODUCTION

- Many techniques for visualization of CFD
 - **Vector arrow plots, Contours, Isosurfaces**
 - **cut planes, streamlines, particle animation**
- Main problem: Comprehension of spatial structures of flow field
- Particle Tracing (Advection) - magnitudes of flow velocity
- BUT - less precise direction/position due to 2D screen ambiguities



INTRODUCTION CONT...

- => Streamlines + Rotational aspects as a ribbon (field vorticity) BUT can lead to cluttered display
- Shade LINES -> accurate visualization of 3D structure (LARGE VOLUMES)
- Spectacular results, More visual cues to structure



- Demos (Live in Express)
 - **Intro to surface lighting - why it helps**
 - **Basic Wave example to show technique**
 - **Basic circles example to illustrate benefits**
 - **Real example - Molecular Viz**



BASIC OUTLINE OF TECHNIQUE

- Texture map capabilities of OpenGL used
- Generate appropriate texture map
- Use an advanced shading model
- First construct texture map and then use it to texture the lines at runtime (during animation)
- Combines particle tracing and geometric stream ribbon, and includes the advantages of both



RELATED SYSTEMS

- QUAKE engine from gaming world
- Tomb Raider





RELATED SYTEMS CONT....

- Sine wave uv offsets applied for bubbling lava pits and waves on water
- Illuminated lines exploits these technologies via the OpenGL API
- Why OpenGL? -> Raw drawing speed and versatility of object construction
- IL first introduced in the OpenInventor system (Zockler 1996, Stalling 1997)



ANIMATED TEXTURES

- Point Path Integration lies at the heart of the streamlines/particle advection techniques
- Obtain points, draw polylines
- Animate via pulses of texture that yields particle movement animation
- Avoid RGB interpolation - assign texture coordinates based on a mapping to numerical scalar fields
- Encode BRDF into the texture to allow for more complex shading models



PERCEPTUAL ENHANCEMENT

- Depth Ordering of Lines - a synthetic artistic presentation effect
- Originally achieved via rendering of black thick lines before the field line render
- BUT - reliance on BG colour
- Solution is to use Invisible Halo Technique
- BG may show through the halo space around the illuminated lines
- Effectively an influence mask (`glDepthMask()`)
- Improve rendering speed



LINE TRANSPARENCY

- Greater insight into internal structure of a field
- Depth Mask toggle to improve depth sorting results
- Improvements when antialiasing the lines is also seen with active depth mask

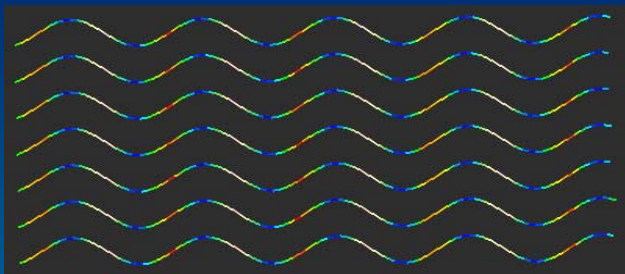


PULSE ANIMATION

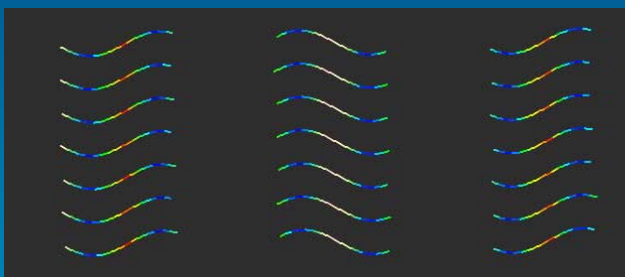
- Geometry and Texture remain static
- Can be pre-computed and therefore cached
- Increase rendering speed by only changing the u-v texture coordinates or by using variable line widths
- Several animation options
 - **Stair**
 - Up, Down and triangle wave
 - **Dash**
 - Active Zone width of 1 OR 100% transparent



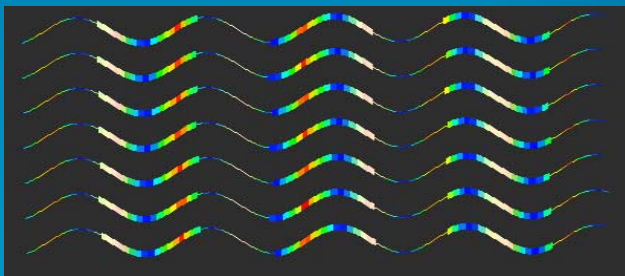
ANIMATION EFFECTS - DASH



No Animation



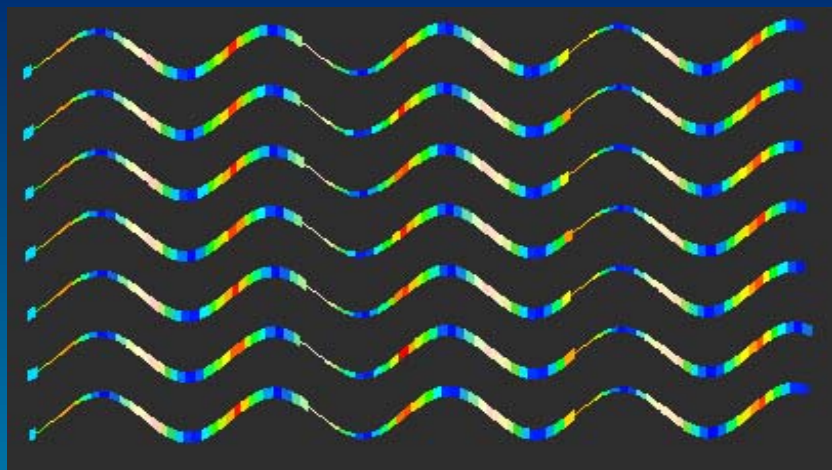
Dash Animation,
modulating transparency



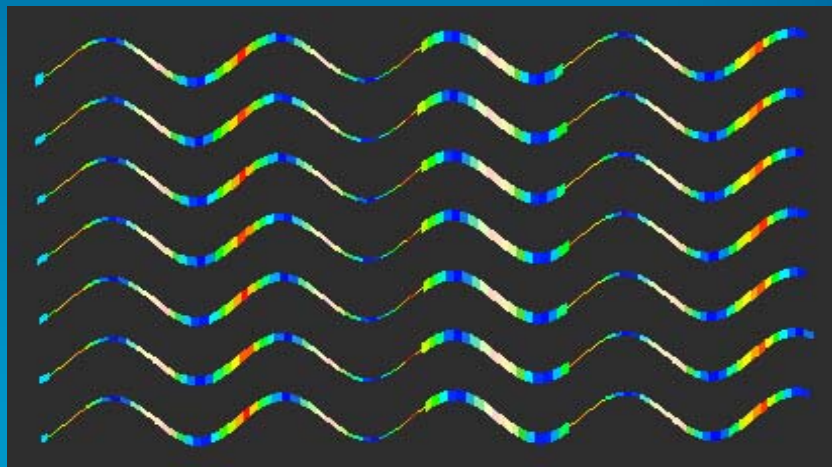
Dash Animation,
modulating width



ANIMATION EFFECTS - STAIR



Stair UP,
modulating width

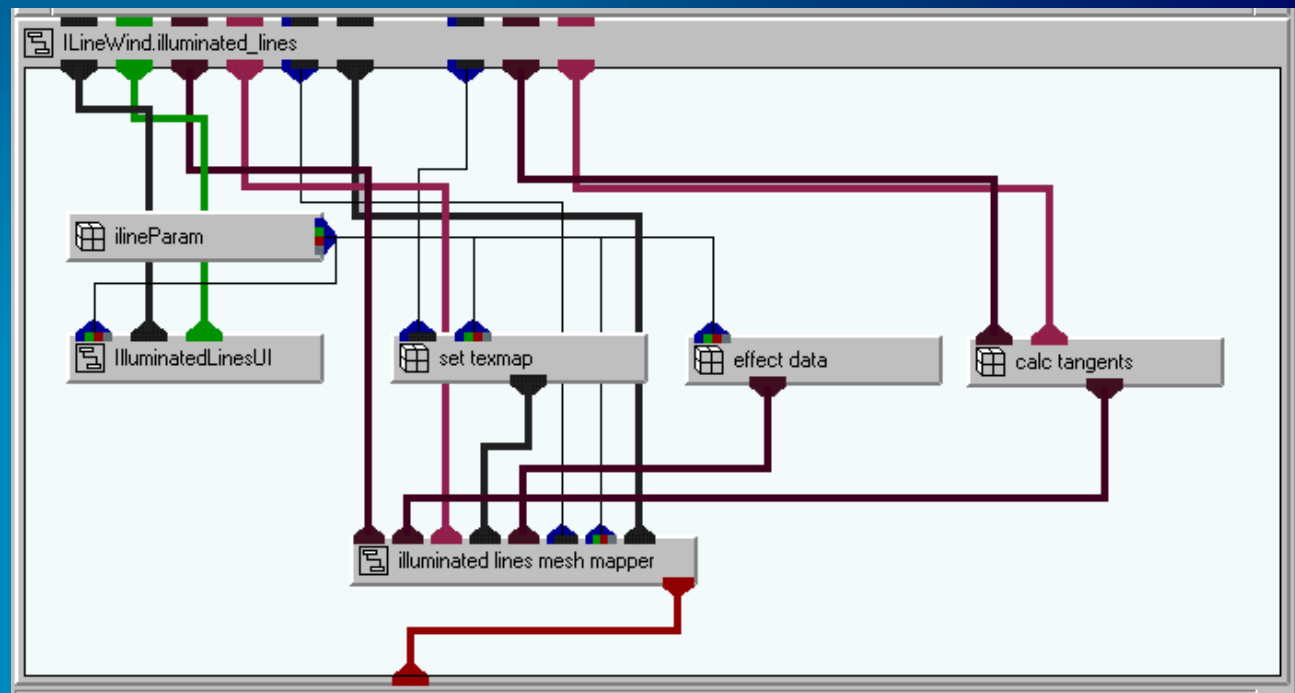
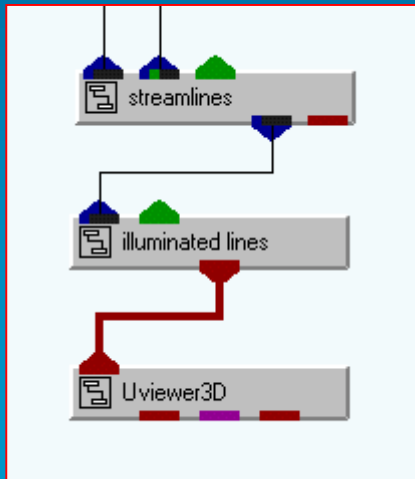


Stair UP and DOWN,
modulating width



IMPLEMENTATION

- AVS/Express - modular, visual application builder
- Integration of custom C++ code





EXAMPLES

- Demos to end (LIVE in Express)
 - **Spring/Coil example**
 - **Buildings example**



CONCLUSIONS...

- Illuminated Lines is a technique for combining Streamlines with Particle Advection
- OpenGL API based, effective utilisation of modern graphics hardware
- Yields stunning visual effects for the visual perception of lines in CFD Data



QUESTIONS ??
