National Institute of Standards and Technology

Smokeview

A Tool for Visualizing Fire and Smoke Flow

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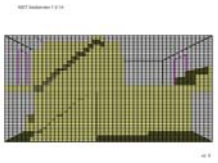
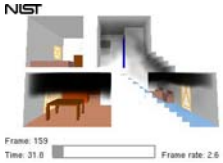
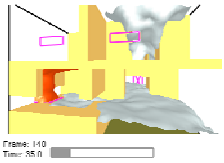
What is Smokeview?

Making Visualization as Accurate as Computation

- **Smokeview** is a visualization tool developed by NIST for visualizing fire and smoke flow dynamics predicted by the Fire Dynamics Simulator (FDS). Smokeview is also used to visualize results of the NIST zone fire model CFAST.
- **FDS** solves numerically a form of the Navier-Stokes equations appropriate for low-speed, thermally-driven flow with an emphasis on smoke and heat transport from fires.







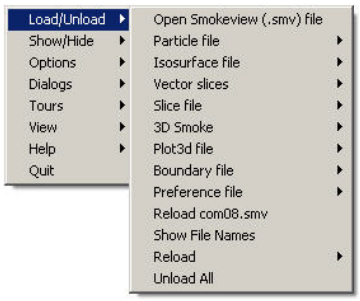
Obtaining Smokeview

- Download the installation program for Smokeview and FDS from **http://fire.nist.gov/fds** *(click on the "download" link)*
- Run the downloaded setup program.
- The setup program installs the Smokeview and FDS software, documentation, sample cases and database files.

Getting Started

Running and Viewing a Sample Case

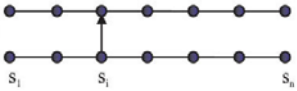
- The default location for sample cases is *c:\nist\fds\samples4*
- Open a command shell (Under Windows XP select the menu item at *start/Programs/Accessories/Command Prompt* .
- To run the townhouse case type:
  cd c:\nist\fds\samples4\thouse4
  fds4 < thouse4.data
- To visualize the case, double-click on **thouse4.smv**.
- Bring up the *Load/Unload* menu by right-clicking anywhere in the geometry window.
- Select the desired file to view
- Use the *Open Smokeview* menu to start any smokeview file.
- Use the *Preference* menu to save and restore settings.
- Select other menus to refine how the scene is viewed.



Using Transparency to Visualize Smoke

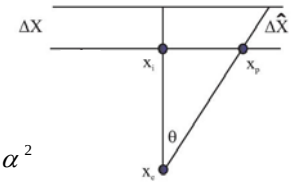
Physics-based computation of smoke transparency

- FDS computes and compresses obscurations, α_i (using Δx between adjacent grid planes) at each grid node using soot density data, s_i, and Beer's law, $\alpha_i = 1 - \exp(-k s_i \Delta x)$



- Smokeview adjusts each α_i in real time for non-axis aligned view distances $\Delta\hat{X}$ using

$$\hat{\alpha} = 1 - (1-\alpha)^{\Delta\hat{x}/\Delta x}$$

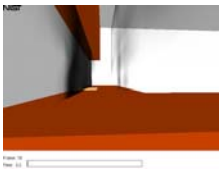


- Smoke may be drawn faster by skipping planes (need to adjust α's for planes that remain)

$$\Delta\hat{X}/\Delta X = 2 \Longrightarrow \hat{\alpha} = 1-(1-\alpha)^2 = 2\alpha - \alpha^2$$

- Computation of $\hat{\alpha}$ may be speeded up by using Taylor series approximations for non-integer $\Delta\hat{X}/\Delta X$
- Smokeview draws a series of parallel slice planes (back to front) using **black** to represent soot color and adjusted α's to represent opacity

3D smoke display using transparency



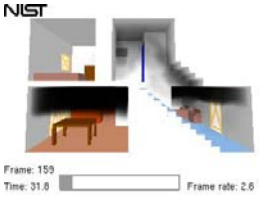
Side view (between two slices)

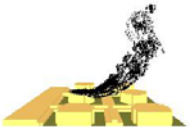
Front view

Techniques for Visualizing Fire and Smoke Flow

Providing Insight Not Numbers

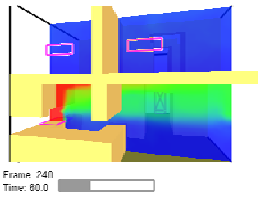
Realistic/3D Smoke FDS computes *soot density* over the entire 3D domain. It converts and compresses this data to values used by **Smokeview** to draw a series of parallel, partially transparent planes.

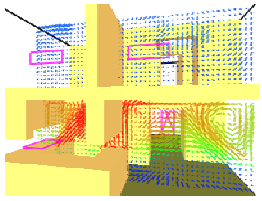




PARTICLES move along "with the flow" as computed by FDS. They are colored according to their temperature or whether they are soot or water (sprinkler droplet).

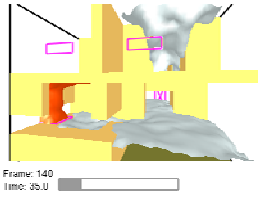
SLICES Animated contours are drawn using grid point data in selected slice planes. The data are colored according to their temperature, density, *etc*. Use **&SLCF PBY=1.5 QUANTITY='TEMPERATURE' /** to generate temperature slice contours 1.5m along the *Y axis*.

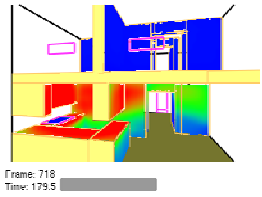




VECTOR SLICES Adding **VECTOR=.TRUE.** to a **&SLCF** line creates data for an animated vector plot. Vector lengths and directions are drawn using velocity data. Vectors are colored (as in a slice file) using temperature, heat release rate data, *etc*.

ISOSURFACES Animated 3D contours are drawn where temperature, mixture fraction, *etc*. data attains a desired value. To generate animated isosurfaces of temperature at 300 ^{0}C and 50 ^{0}C, add **&ISOF QUANTITY='TEMPERATURE', VALUE(1)=300.0,VALUE(2)=50.0 /** to the input file.



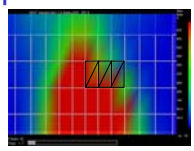


BOUNDARIES Boundary animations use data recorded at surface blockages and the boundary of the domain. Shaded contours are drawn for quantities such as wall surface temperature, radiative flux, *etc.* To generate animated temperature boundary plots add the line **&BNDF QUANTITY="WALL_TEMPERATURE" /** to the input file.

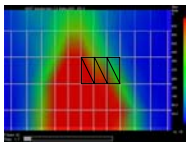
Using Color and Shape to Visualize Smoke

2D Shaded Contours

- Draw shaded triangles specifying color and location of each vertex.
- Improve color interpolation by triangulating to follow contours in data
- Triangulate along data contours to improve color interpolation

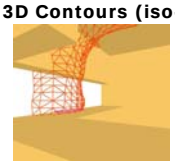


Triangles do not follow contour levels



Triangles do follow contour levels

3D Contours (iso-surfaces)



Determine triangles that follow level surface.

Faceted level surface. Normal vectors the same for each vertex in triangles.

Smooth level surface. Normal vectors at each vertex averaged from adjacent triangles.

FEMA

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