Visualization of Fluid Dynamics at NASA Ames

Val Watson
NASA Ames Research Center

The hardware and software currently used for visualization of fluid dynamics at NASA Ames is described. The software includes programs to create scenes (for example particle traces representing the flow over an aircraft), programs to interactively view the scenes, and programs to control the creation of video tapes and 16mm movies. The hardware includes high performance graphics workstations, a high speed network, digital video equipment, and film recorders.

With the current workstations, a scientist can interactively view flow over simplified objects, such as the flow over a circular cylinder. For complex objects, such as an aircraft, the workstation creates each picture too slowly to gain a sense of the dynamics of the flow. Therefore, each picture is stored frame by frame on a video tape or 16mm film and then the video or movie is played back at normal speed to illustrate the flow dynamics.

The upgrade in workstations planned for this year is expected to permit moderately complex pictures (pictures that can be represented by 10,000 polygons or less) to be created at a rate of 10 frames per second --- fast enough to gain a sense of the flow dynamics. Therefore, these workstations should permit interactive viewing of the flow over complete aircraft rather than just simple objects. Upgrades planned this year for software should provide a more effective interface for controlling the interactive viewing.

A comparison of the upgrades planned this year with an ideal simulation and visualization environment shows that there is still potential for major improvements in both software and hardware. The greatest potential for improving the environment is the development of software to extract and illustrate the essence of very complex phenomena.

Results presented by other scientists during this conference clearly demonstrate the effectiveness of the current visualization tools for assisting in the understanding of complex simulations, but it is also clear that we are a long way from utilizing visualization tools to their full extent.
Outline

NASA's current visualization tools
Capabilities with the current tools
Upgrades planned for this year
Potential for further improvements
Conclusions
Video Recording System

Scan Converter R G B high resolution

Encoder R G B high resolution

Video Switcher NTSC

Digital Effects digital NTSC

Video Recorder NTSC

Disk System NTSC

Workstation

RS 170 (low res)

Not shown
Sync. generator
Time base corrector
Amplifier and monitors
## Software

<table>
<thead>
<tr>
<th>Simulation</th>
<th>Visualization and Recording</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scene Creation</td>
<td>Scene Viewing</td>
</tr>
<tr>
<td>Animation Sequence</td>
<td>Recording on Film and Video</td>
</tr>
</tbody>
</table>

- PLOT3D
- SURF
- CPLANE
- RIP
- GAS
Current Capabilities in Visualization

Interactive viewing with workstations
  Dynamic illustration of wire frame objects
  Dynamic illustration of simple solid objects
  Static illustration of complex solid objects

Playback viewing with video or film
  Dynamic illustration of complex solid objects
Upgrades in Workstations Planned this Year

Basic Workstation features
- Central processor from 2600 to 2000 Dhrystones
- Arith processor from 0.1 to 6.0 MFLOPS
- Primary memory from 4 to 32 MBytes
- Secondary mem. from 474 to 1000 MBytes

Graphics Features
- 3D coord. transf. from 80K to 800K coord./sec
- Solids rendering from 0.5K to 100K polygons/sec
  (= 10,000 polygons at 10 frames/sec)
Upgrades in Software Planned this Year

Combination of old modules into a single program
Changes to take advantage of new workstations
Changes to make visualization more interactive
Comparison of Current Capabilities with "Ideal" for Vision

<table>
<thead>
<tr>
<th>Feature</th>
<th>Current</th>
<th>&quot;Ideal&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>spatial res.</td>
<td>1 minute of arc</td>
<td>of the same order</td>
</tr>
<tr>
<td>color res.</td>
<td>16 million colors</td>
<td>of the same order</td>
</tr>
<tr>
<td>freq. resp.</td>
<td>(scene dependent)</td>
<td>15 frames/sec</td>
</tr>
<tr>
<td>field of view</td>
<td>1/5 steradian</td>
<td>5 steradians</td>
</tr>
</tbody>
</table>
Comparison of the Ideal vs Current Field of View

Field of view of the human eyes

Field of view of 19" display
Comparison of Current Capabilities with "Ideal" for Interactive Control

Current
mouse and keyboard

"Ideal"
6-degree of freedom control
voice recognition
Potential for Improvements in Software

Tools for extraction of critical features

Tools for highlighting critical features and suppressing less important features
CONCLUSIONS

The NAS decision to invest in visualization tools has been justified by improved analysis capabilities.

The most effective use of vis. tools is the routine interactive viewing of solutions and techniques.

Current workstations permit interactive viewing of the flows over simple shapes.

Workstations to be procured should permit interactive viewing of flows over complex shapes.
CONCLUSIONS (continued)

A new generation of software is being developed to take advantage of new workstation capabilities to make the visual analysis more interactive.

The most critical task is overcoming visual clutter developing techniques to extract the "essence" developing techniques to illustrate the "essence"

We are a long way from utilizing our present visualization tools completely.
For Further Information

NAS procurement for the new workstations
  Rosemary Buchanan
  Mail Stop 258-6
  NASA Ames Research Center
  Moffett field, CA 94035
  (415) 694-4610

Scientific visualization materials
  Stanford report on automated feature extraction
  1988 CFD Highlights video
  Stereo slides
    Pat Mumford Elson
    Mail Stop 258-2
    NASA Ames Research Center
    Moffett Field, CA 94035
    (415) 694-4463