MiniWall Tool for Analyzing CFD and Wind Tunnel Large Data Sets

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• Main Image Table
• Multi-Image Window
• Single-Image Window
• Demonstration
• Help Window
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• Summary & Conclusions
Motivation

• Visualize large data sets
• Make comparisons between different “runs”
• Extract knowledge and understanding

Inspired by NASA Ames NAS computer system hyperwall created in 2002
• Scalable concurrent visualization of Typhoon Morakot from different perspectives at the same time (left)
• Visualize large simulations (right)
Motivation (continued)

- CFD and Wind Tunnel tests typically have large run matrices
- Wanted to extract knowledge and understanding from gobs of data
- Needed a better way to view results buried in a bunch of folders

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Angle of Attack</th>
<th>Side Slip Angle</th>
<th>Mach</th>
<th>Altitude</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline-aircraft</td>
<td>0</td>
<td>0</td>
<td>0.72</td>
<td>45</td>
<td>High</td>
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<tr>
<td>Baseline-aircraft</td>
<td>0</td>
<td>2</td>
<td>0.72</td>
<td>45</td>
<td>High</td>
</tr>
<tr>
<td>Baseline-aircraft</td>
<td>4</td>
<td>0</td>
<td>0.72</td>
<td>45</td>
<td>High</td>
</tr>
<tr>
<td>Baseline-aircraft</td>
<td>8</td>
<td>0</td>
<td>0.72</td>
<td>45</td>
<td>High</td>
</tr>
<tr>
<td>Baseline-aircraft</td>
<td>12</td>
<td>0</td>
<td>0.72</td>
<td>45</td>
<td>High</td>
</tr>
<tr>
<td>Baseline-aircraft</td>
<td>0</td>
<td>0</td>
<td>0.25</td>
<td>0</td>
<td>Med</td>
</tr>
<tr>
<td>Baseline-aircraft</td>
<td>6</td>
<td>0</td>
<td>0.25</td>
<td>0</td>
<td>Med</td>
</tr>
<tr>
<td>Baseline-aircraft</td>
<td>8</td>
<td>0</td>
<td>0.25</td>
<td>0</td>
<td>Med</td>
</tr>
<tr>
<td>Baseline-aircraft</td>
<td>12</td>
<td>0</td>
<td>0.25</td>
<td>0</td>
<td>Med</td>
</tr>
<tr>
<td>Baseline-aircraft</td>
<td>0</td>
<td>5</td>
<td>0.25</td>
<td>0</td>
<td>Low</td>
</tr>
<tr>
<td>Baseline-aircraft</td>
<td>6</td>
<td>5</td>
<td>0.25</td>
<td>0</td>
<td>Low</td>
</tr>
<tr>
<td>Baseline-aircraft</td>
<td>0</td>
<td>10</td>
<td>0.25</td>
<td>0</td>
<td>Low</td>
</tr>
<tr>
<td>Baseline-aircraft</td>
<td>6</td>
<td>10</td>
<td>0.25</td>
<td>0</td>
<td>Low</td>
</tr>
<tr>
<td>Baseline-aircraft</td>
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<td>15</td>
<td>0.25</td>
<td>0</td>
<td>Low</td>
</tr>
<tr>
<td>Baseline-aircraft</td>
<td>6</td>
<td>15</td>
<td>0.25</td>
<td>0</td>
<td>Low</td>
</tr>
<tr>
<td>Modified-aircraft</td>
<td>-4</td>
<td>0</td>
<td>0.78</td>
<td>45</td>
<td>High</td>
</tr>
<tr>
<td>Modified-aircraft</td>
<td>-2</td>
<td>0</td>
<td>0.78</td>
<td>45</td>
<td>High</td>
</tr>
<tr>
<td>Modified-aircraft</td>
<td>0</td>
<td>0</td>
<td>0.78</td>
<td>45</td>
<td>High</td>
</tr>
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<td>0</td>
<td>0.78</td>
<td>45</td>
<td>High</td>
</tr>
</tbody>
</table>
Motivation (continued)

The MiniWall

- Provides for easy and interactive data exploration (slice & dice)
- Allows many images to be displayed simultaneously
- Displays results in the natural context of the test – i.e. Mach versus AoA
- Allows drilling down into the data
- Share the data with others and enable them to explore the data

Pressure in 40’x80’ NASA Wind Tunnel
Software History

• Originally written in 2006 by John Melton in Microsoft’s ActiveX and JavaScript software. Only ran on Windows computers.

• Paul Stremel rewrote it several years later using JavaScript. This enabled MiniWall to run many different kinds of computers and devices.

• Michael Schuh rewrote it in 2016 to use JavaScript objects and added several new features. Started serving up the pages using webserver nginx and https.
SLS Venting Project

- The images in the paper and demonstration are from the NASA Space Launch System (SLS) venting project.

**Venting project investigated a new honeycomb vent design to better vent air from inside the shell as the rocket flies to outer space.**

**Apollo Saturn V Cutaway showing air space between internal components and shell.**

**NASA SLS Rockets**

- 70 ton
- 105 ton
- 130 ton
How to View a MiniWall

- MiniWall can be opened from a local html file or URL
  - File
    - MiniWall Aurora.html
  - URL example, the MiniWall below is being served by an HTTP server through an SSH tunnel. The page requires a user name and password to be accessed.
Three Main Views

Main Image Table

Multi-image Window

Single-image Window
Three Main Views

Main Image Table

Multi-image Window

Single-image Window
Main-Image Table

- User first sees the Main-Image Table
- CFD simulations of a honeycomb vent design analyzed for the Space Launch System (SLS) rocket

Pressure Ratio

Geometry (Different vent diameters)
Main-Image Table Controls

- Controls are located at the bottom of the screen
- Also controlled by the mouse and keyboard
Main-Image Table Controls

- Columns and rows can be hidden by clicking on the column or row title.
- The “u” key unhides all hidden columns and rows.
- Clicking on pink squares unhides a hidden column or row.
Three Main Views

Main Image Table

Multi-image Window

Single-image Window
Multi-Image Window

- Shows all available images for a data set in main image table

20141029 FML_Sqr7.2ha45pt1hw4.5hs0.1875_Mach0.9_Pte77136_Ite320_Irat0.85_Prat1.20_BLVer0.9-Aa_Base4.0_Mesh2.20_Poly_Pr112Str1.075bl12_Coupled - 20%
Three Main Views

Main Image Table

Multi-image Window

Single-image Window
Single-Image Window

- Shows large view of image from main image table or multi-image window
- Use “Shift-left-mouse” click to open an image in a single-image window
**MiniWall Help**

Brief list of keys for controlling the MiniWall behavior

<table>
<thead>
<tr>
<th>Key and/or Mouse Click</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>Show or hide all of the images that did not load in a multi-image window</td>
</tr>
<tr>
<td>j</td>
<td>Next image</td>
</tr>
<tr>
<td>J</td>
<td>Reduce the image scale by 1%</td>
</tr>
<tr>
<td>Right Arrow</td>
<td>Next image</td>
</tr>
<tr>
<td>Left-Mouse-Click</td>
<td>Next image (only for the clicked image)</td>
</tr>
<tr>
<td>h</td>
<td>This help message</td>
</tr>
<tr>
<td>k</td>
<td>Previous image</td>
</tr>
<tr>
<td>K</td>
<td>Increase the image scale by 1%</td>
</tr>
<tr>
<td>L</td>
<td>Link all of the single image windows and the main image window so that they all show the same image. Currently false.</td>
</tr>
<tr>
<td>Ctrl-Left-Mouse-Click</td>
<td>Previous image (only for the clicked image)</td>
</tr>
<tr>
<td>Left-Arrow</td>
<td>Previous image</td>
</tr>
<tr>
<td>Shift-Left-Mouse-Click</td>
<td>Open a new window with the current image. Works in main image table and multi-image windows.</td>
</tr>
<tr>
<td>Shift-Alt-Left-Mouse-Click</td>
<td>Open a new multi-image window with all of the images for the image selected</td>
</tr>
<tr>
<td>p</td>
<td>Raise all of the single image windows. This will bring them to the top in the order they were opened.</td>
</tr>
<tr>
<td>q</td>
<td>Close the current help or single image window</td>
</tr>
<tr>
<td>Q</td>
<td>Close all of the single image and help windows</td>
</tr>
<tr>
<td>r</td>
<td>For the main table window, reset the images to have the original image size of 40%. For the single image windows, reset the size to 100%</td>
</tr>
<tr>
<td>R</td>
<td>Link or unlink all of the single image windows resize events together. Currently false with size undefined%</td>
</tr>
<tr>
<td>t</td>
<td>Transpose the table</td>
</tr>
<tr>
<td>u</td>
<td>Unhide all of the hidden rows and columns in the main image table</td>
</tr>
<tr>
<td>Left-Click on row or column title</td>
<td>Hide all of the images in the given row or column</td>
</tr>
<tr>
<td></td>
<td>Unhide all of the images in the next or previous row or column. The yellow box is only present when a column or row is hidden.</td>
</tr>
</tbody>
</table>

**Multi-Image Window**

<table>
<thead>
<tr>
<th>Key and/or Mouse Click</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shift-Left-Mouse-Click</td>
<td>Open a new single image window with the current image. Works in main image table and multi-image windows.</td>
</tr>
<tr>
<td>Left-Mouse-Click</td>
<td>Set the image in the main image table to the selected image by default. If the &quot;L&quot; link single images option is active, then set the images in the single image windows to the selected image. If the &quot;L&quot; link all images option is active, then set the images in the single image windows and the main image window to the selected image.</td>
</tr>
</tbody>
</table>
Configuration – MiniWall.html

- MiniWall.html file is used to make main-image table
- Specifies two JavaScript files used to setup and run the MiniWall
- Has a few configuration parameters

```
1 <HTML>
2 <HEAD>
3  <script src="javascripts/utils_object.js"> </script>
4  <script src="javascripts/setup_vvent_object.js"> </script>
5 <SCRIPT>
6 /*
7   * Michael Schuh
8   * NASA Ames Research Center Code AA
9   * Moffett Field, CA 94035
10  *
11  * MiniWall Software
12  * 2016-04-14 Version 2.1 Inspired by the MiniWall created by John Melton in 2006 and reworked by Paul Stremal
13  */
14 // Initial values to select the initial image and scaling of the images.
15 // The first index in a list is "0"
16 initial_image_index = 205;
17 initial_size_in_percent = 25;
18 initial_selected_configuration_index = 0;
19 initial_selected_mach_number_index = 0;
20 miniwall_page_tab_name = "Venting MiniWall";
21 // Tell the utilities.js tools what type of miniwall controls to use
22 miniwall_type = "venting";
23 </SCRIPT>
24 </HEAD>
25 <BODY onLoad='createObjectTablePage();'> </BODY>
26 </HTML>
```
// Miniwall setup parameters
var row_data_sets = [];
row_data_sets.push("Sqr7_2ha45pt1hw4.5hs0.1875;Mach0.9;Pte77136;Tte320;Trat0.85;BLVer0.9;AoABase4.0;Mesh1.20;Pr12Str1.075bl12_Coupled");
row_data_sets.push("Sqr5.091ha45pt1hw4.5hs0.1875;Mach0.9;Pte77136;Tte320;Trat0.85;BLVer0.9;AoABase4.0;Mesh1.20;Pr12Str1.075bl12_Coupled");
row_data_sets.push("Sqr5.091ha45pt1hw4.5hs0.1875;Mach0.9;Pte77136;Tte320;Trat0.85;BLVer0.9;AoABase4.0;Mesh1.20;Pr12Str1.075bl12_Coupled");

// Mach 1.4
row_data_sets.push("Sqr7.2ha45pt1hw4.5hs0.1875;Mach1.4;Pte77131;Tte320;Trat0.85;BLVer0.9;AoABase4.0;Mesh1.20;Pr12Str1.075bl14_Coupled");
row_data_sets.push("Sqr5.091ha45pt1hw4.5hs0.1875;Mach1.4;Pte77131;Tte320;Trat0.85;BLVer0.9;AoABase4.0;Mesh1.20;Pr12Str1.075bl14_Coupled");
row_data_sets.push("Sqr5.091ha45pt1hw4.5hs0.1875;Mach1.4;Pte77131;Tte320;Trat0.85;BLVer0.9;AoABase4.0;Mesh1.20;Pr12Str1.075bl14_Coupled");

var column_values = [];
column_values.push("1.02");
column_values.push("1.05");
column_values.push("1.10");
column_values.push("1.20");

var configuration_basename='20140229_FMP';
var column_label_prefix='Prat';
var image_filename_extension='png';
image_extension_names =";
Solution_Mach \
Solution_Mach_closeUpRight \
Solution_Mach_closeUpRightMesh \
Solution_Mach_closeUpTop \
Solution_Mach_closeUpTopMesh \
[not shown]

var configurations = new Array();
configurations.push("All");
configurations.push("Sqr5.6ha45pt1hw4.5hs0.1875");
configurations.push("Sqr5.691ha45pt1hw4.5hs0.1875");
configurations.push("Sqr7.2ha45pt1hw4.5hs0.1875");

var mach_numbers = new Array();
mach_numbers.push("All");
mach_numbers.push("1.02");
mach_numbers.push("1.05");
mach_numbers.push("1.10");
mach_numbers.push("1.20");
Summary & Conclusions

- Easy to work, share, and collaborate on large data sets
- Provides intuitive access to non-experts
- Transforms data into knowledge and understanding
- Enables viewing the data in the natural context of the test
- Runs on many devices
- Data can be served remotely and protected by SSH and passwords
- Can be used with any data that can be displayed in an HTML page
- Investigating the software release process to make the MiniWall available