MiniWall Tool for Analyzing CFD and Wind Tunnel Large Data Sets

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Outline

• Motivation
• Main Image Table
• Multi-Image Window
• Single-Image Window
• Demonstration
• Help Window
• Configuration Files
• 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>-4</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>0.72</td>
<td>45</td>
<td>High</td>
</tr>
<tr>
<td>Baseline-aircraft</td>
<td>2</td>
<td>0</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>4</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>10</td>
<td>0</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>
<td>0</td>
<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>
</tbody>
</table>

| Modified-aircraft | -4              | 0               | 0.78 | 45       | High     |
| Modified-aircraft | -2              | 0               | 0.78 | 45       | High     |
| Modified-aircraft | 0               | 0               | 0.78 | 45       | High     |
| Modified-aircraft | 2               | 0               | 0.78 | 45       | High     |
| Modified-aircraft | 4               | 0               | 0.78 | 45       | High     |
| Modified-aircraft | 6               | 0               | 0.78 | 45       | High     |
| Modified-aircraft | 8               | 0               | 0.78 | 45       | High     |
| Modified-aircraft | 10              | 0               | 0.78 | 45       | High     |
| Modified-aircraft | 12              | 0               | 0.78 | 45       | High     |
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.
The images in the paper and demonstration are from the NASA Space Launch System (SLS) venting project. The venting project investigated a new honeycomb vent design to better vent air from inside the shell as the rocket flies to outer space.
How to View a MiniWall

- MiniWall can be opened from a local html file or URL
  - File

- 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
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 together so that they all show the same image. Currently false.</td>
</tr>
<tr>
<td>L</td>
<td>Link images together in 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>
<tr>
<td>Multi-Image Window</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>Shift-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>

---

Use “h” key for “help”
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

```html
1 <HTML>
2 <HEAD>
3 <script src="javascripts/utils_object.js"> </script>
4 <script src="javascripts/setup_vent_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 = 0;
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 utils_object.js tools what type of miniwall controls to use
22 miniwall_type = "venting";
23 </SCRIPT>
24 </HEAD>
25 </BODY onLoad='createObjectTablePage()'> </BODY>
26 </HTML>
```
Configuration – Setup_vent_object.html

• Defines lists of data sets, column values, image names, and other control options

```javascript
// Miniwall setup parameters
var row_data_sets = [];
row_data_sets.push({"Sqr7.2ha45pt1hw4,5hs0,1875=Mach0.9;Pte77135;Tte320;Tra0.85;BLVer0.9;Aa=Base4.0;Mach2.0;Pr112Str1_075bl12_Coupled"});
row_data_sets.push({"Sqr5.091ha45pt1hw4,5hs0,1875=Mach0.9;Pte77135;Tte320;Tra0.85;BLVer0.9;Aa=Base4.0;Mach2.0;Pr112Str1_075bl12_Coupled"});
row_data_sets.push({"Sqr5.091ha45pt1hw4,5hs0,1875=Mach0.9;Pte77135;Tte320;Tra0.85;BLVer0.9;Aa=Base4.0;Mach2.0;Pr112Str1_075bl12_Coupled"});
row_data_sets.push({"Sqr7.2ha45pt1hw4,5hs0,1875=Mach1.4;Pte77131;Tte320;Tra0.85;BLVer0.9;Aa=Base4.0;Mach2.0;Pr112Str1_075bl14_Coupled"});
row_data_sets.push({"Sqr5.091ha45pt1hw4,5hs0,1875=Mach1.4;Pte77131;Tte320;Tra0.85;BLVer0.9;Aa=Base4.0;Mach2.0;Pr112Str1_075bl14_Coupled"});
row_data_sets.push({"Sqr5.091ha45pt1hw4,5hs0,1875=Mach1.4;Pte77131;Tte320;Tra0.85;BLVer0.9;Aa=Base4.0;Mach2.0;Pr112Str1_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='20141029_FML'; // configuration name
var column_label_prefix='Prat'; // x-axis label [A for AoA, etc.]
var image_filename_extension='png';
var image_extension_names ="\nSolution_Mach \nSolution_Mach_closeUpRight \nSolution_Mach_closeUpRightMesh \nSolution_Mach_closeUpTop \nSolution_Mach_closeUpTopMesh 
[lines not shown]
```

};

var configurations = new Array();
configurations.push("All");
configurations.push("Sqr5.091ha45pt1hw4,5hs0,1875");
configurations.push("Sqr5.091ha45pt1hw4,5hs0,1875");
configurations.push("Sqr7.2ha45pt1hw4,5hs0,1875");

var mach_numbers = new Array();
mach_numbers.push("All");
mach_numbers.push("1.01");
mach_numbers.push("1.4");
mach_numbers.push("1.4");
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