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Group Report
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3D Visualization of the Aerodynamics of Bat Flight

We approached the task of visualizing the aerodynamics of bat flight by critically examining the current flow simulation and then imagining additions and refinements to improve it. The current tools for visualizing the bat flight simulation is very simple and fail to convey spatial and temporal scale. We thus devised a new design for the bat flight simulation addressing the aforementioned criticisms. As a result, the objective of our visualization has been to create an aesthetic virtual world in which each element serves a functional purpose that we hope will be useful to the scientific viewer. To achieve our objective, we have designed the following elements: environment, bat wing shader, cutting planes, 3D star icons, pathlines, control panel and hardware.

Environment

The environment follows a tropical jungle theme to give a sense of the bat in its natural environment. The walls of the CAVE are textures that move according to the speed of the flying bat. The floor of the CAVE is a moving texture depicting a river upon which the stars in the sky reflect. We had designed the option for having a mirror plane superimposed upon the river's surface to reflect the air pressure data on the underside of the bat wings, This mirror plane could be turned on and off. The mirror plane was not implemented, however.

Air Pressure On The Bat Wings: The Bat Shader with Bone Texture

The current simulation represents the bat as a planar wire frame upon which textures may be placed. , To improve upon the current simulation, we have designed a bat wing shader that is a color map superimposed on either one or both sides of the wire frame bat. For our simulation, we have created a shader that rests on the top and bottom of the wings because the data varies across the wings surfaces. The color map changes along a gradient to reflect the air pressure on the wings. High pressure is golden and low pressure is reddish-brown. An option on the control panel will allow the shader to be turned on and off.

Cutting Planes

We have designed cutting planes as one of our main tool for examining the airflow data. The cutting planes are 2D planes that can be moved through the bat and airflow in any direction. Additionally, the cutting plane can be "snapped" to the closest XY/XZ/YZ axis.

The cutting planes can show one of the following types of data: air pressure, velocity and vorticity.

Air pressure data is represented on the cutting plane by a color map that varies from red to blue, where red shows high pressure; blue, low; and transparent, medium.

Velocity data is represented by two scales: direction and speed. For speed, a green color map that varies in opacity has been designed; opaque green represents the fastest speed and decreasing opacity represents decreasing speed. For direction, we had designed

arrows; however, they have not been created.

Vorticity data is represented by two scales: direction and magnitude. For magnitude, a yellow color map that varies in brightness has been designed; brightest yellow corresponds to the greatest magnitude, and lightest yellow, the smallest magnitude.

More than one type of data for the same location may be viewed simultaneously by stacking the desired number of planes near each other, each depicting the desired data. We designed this option to give the scientific user the opportunity to grasp a more comprehensive view of the airflow data.

3D Star Icons and Pathlines

A star icon replaces the particle used in the current simulation to show air flow around the bat. The star icon depicts the following information: air pressure and velocity. The air pressure gradient is the same used in the cutting plane: red to blue shows high to low air pressure. Velocity is shown by the brightness of the color: the brighter, the faster. We have chosen to ignore vorticity because it is already visualized via one of the cutting plane modes and the icons are too small to actually distinguish such information. The size of the stars and the number of stars (density of stars in the flow) to be manipulated.

The pathlines are comprised of a chain of stars in which each subsequent star is smaller and fades in saturation. Each star in the chain represents the previous positions of leading star in the flow, which is the largest, most saturated star. The pathlines can be turned on and off and their lengths can be changed.

The Control Panel: The Control Jewel

The current simulation's control panels are simple, dull blue menus that are more inconvenient than helpful. They are inconvenient because they use a lot of the space in the CAVE, often impeding in the user's ability to view the visualization. Therefore, the objective of our design for the control panel was to create an aesthetic interface tool that would allow the user to easily manipulate the visualization, while displaying the most options in the least amount of space. We have designed a control panel that is a 3D octahedron in which the sides of the octahedron correspond to the various elements of our project. The name "control jewel" has been adopted to describe the control panel because the vibrant colors and shape of the panel resembles a jewel.

The following are brief descriptions of the sides of the control jewel:

1. Time Control – this side has play, pause, step forward and step backward buttons, and a slider to scrub through the frames.
2. Icon Control – this side has a two buttons to increase and decrease the size of the icons and a slider to manipulate the number of icons. In addition, there is a button to turn pathlines on and off and a slider to change the length of the pathline.
3. Bat Control – this side has three buttons: one to turn on and off the reflective surface, one to turn on and off the bat shader, and one to turn on and off the wire frame bat.
4. Cutting Plane Control – there are four sides devoted to cutting plane control:
    a. One side is a button to turn on and off the cutting plane displaying air pressure data.
    b. One side is a button to turn on and off the cutting plane

displaying velocity data.

c. One side is a button to turn on and off the cutting plane displaying vorticity data.
d. [need to find out from Julie]

Finally, we have also included a reset button on the control jewel that, when pressed, resets the settings and returns the visualization to its default, starting state.

Hardware

For our hardware, we have used one of the controllers installed in the CAVE. In addition, we have borrowed a scrubber that was made by two members of the class Sascha Becker Shine and Joseph Hocking. The scrubber allows the user to "scrub" forward and backwards through the frames.

In our ideal design, we have imagined a controller that is a wand with five buttons and a slider. The buttons would be the following:

A button for grabbing and moving the control jewel and for selecting options on the control jewel.

A button to show and hide the control jewel.

A button to stop and play again the simulation.

Two buttons to increase/decrease the playback speed.

A slider to step forward and backward by certain number of frame increments.

Conclusion

We have created a project that is the product of the visions of the designers within the realm of coding capabilities. All the while, we have kept in mind the user of our project: the scientist. The process of creating this project has involved constant communication of ideas between all members of the group. In addition, by dividing responsibilities, each member of the group has been able to use his/her time most efficiently by focusing on a few small projects. When put together, these few small projects have allowed us to assemble a cohesive design that, we believe, has achieved our objective: to invent a virtual world with features that make the scientific user's journey an enlightening one.