CPLS 5200 – Scientific Visualization

Our Solar System from 1900AD to 2165AD—DRAFT SUBMISSION

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Informed Design Decisions:

During the construction of this visualization, design principles from Kosslyn's "Looking With the Eye and Mind", were kept in mind and attempted to be adhered to. When considering the aspect of Kosslyn's Principle of Relevance – the decision to present the first view of the solar system from far away – showing the enlarged orbital speed tubes – was made to quickly demonstrate the size of the domain being considered without attempting to show additional details; such as the bodies themselves moving or the orbital arrow glyphs. The Principle of Relevance also motivated the decision to show either the orbital speed tubes or the orbital arrows dominantly at any given time; drawing the audience's attention to each aspect of the visualization sequentially.

Kosslyn's Principle of Appropriate Knowledge heavily influenced the motivation to include semi-realistic textures of the bodies, and a star field in the background. The appearance of the solar system with similar textures is quite familiar to a wide audience. In an attempt to appeal to this large audience, a minimal amount of additional concepts was added to the visualization. It is the hope of the designer that the orbital speed tubes rendered along the orbital paths will provide that same wide audience with a bit of additional information they may not have had prior. Additionally, a text overlay displaying the current Earth year was included to bring further understanding to the display. This familiar standard for denoting time falls well within the targeted audience's knowledge.

Kosslyn's Principle of Salience was considered throughout the construction of several factors in the visualization. The background star field texture was made to be significantly dimmer than the bodies and orbital paths in the visualization, in order to draw attention towards the objects of interest. When constructing the camera motion, care was taken to ensure that the body of interest would remain the focal point of the visualization, yet still draw the audience to be aware of large perceptible differences between orbital paths and body sizes. As the Sun plays a significant role in the visualization—by providing an origin reference point—it is rendered to be significantly larger than the other bodies in the display.

Kosslyn's Principle of Discriminability came into consideration when ensuring that each body would have its own distinct visual representation. Each body has a uniquely textured sphere, in some cases planetary rings, and orbital arrows with unique and distinct colors. The detectability aspect of this principle can also be considered when examining the orbital speed tubes in closer detail. Due to the nature of the system being modeled, some bodies orbit the Sun many more times than others over the same period of time. The visualization uses only the first complete orbital data points to construct a series of rotated cylinders – which are oriented in the direction of movement, uncapped, and slightly transparent to allow the body moving inside of the cylinders to be visible. The series of cylinders constructed in this way forms a tube, yet a closer inspection will reveal a small amount of occlusion which occurs where cylinder ends meet and overlap. These overlaps are not particularly easy to detect, so they have not been highlighted in this visualization; however they do provide the viewer with additional insight into the amount of space traveled for each body during the sample size timestep used in the visualization. For example, if additional work was put into making these marks more detectable, this visualization could also show how far each body moves within a 48 hour period of time.

Kosslyn's Principle of Compatibility was considered specifically when designing the size of each body's sphere representation. The original intent of the visualization was to render the sphere for each body to scale, according to the body's approximate radius, but rendering issues experienced within ParaView required an alternative approach to meet the project deadline. Instead of drawing each planet to scale – each planet is rendered with an approximation in their relative sizes to each other, a larger sphere correlates to a larger body or as Kosslyn effectively puts it “more is more”. Though not entirely accurate, the visualization is still able to express a large difference in size between the bodies.

Kosslyn's Principle of Informative Changes is a principle which could likely categorize many visualization techniques implemented in this project. The change of position in each body between each frame of animation, correlates to the actual motion a body would be taking in space. The changing text overlay informs the viewer that the Earth completed another orbit around the Sun. Alterations in the camera perspective provide viewers with a signal that the new perspective is intending to convey something interesting or new to them.

Kosslyn's Principle of Capacity Limitations was also a factor in the decision to design the movement of the camera to focus on one individual body at a time. Though this does increase the duration of the visualization overall, it provides an interested user with the opportunity to focus on a single body at a time; as opposed to attempting to convey the same amount of information on all the bodies at once.

Intent of the Visualization for Class Audience:

When directed to a more general audience, such as our class, the visualization is meant to convey various amounts of information relating to the planets in our solar system. An attempt has been made to give the viewer a general sense of the scale of the distances between orbital paths and the size of the bodies themselves. In addition, visualization techniques were implemented to present viewers with ways to conceive of the orbital paths, planes, and the variation of speed for a body within its own respective orbit. Lastly, the visualization is also designed to draw viewer attention to how fast the inner solar system bodies complete orbits around the Sun when relatively compared with the outer planets.

The camera perspective is continually moving between approximately 100 anchor points throughout the entire presentation of the visualization. The crafted camera perspectives are intended to address the issue of presenting the scale of the distances between orbital paths and the size of the bodies. An example of using the camera to express the distances between orbital paths can be demonstrated by examining the initial camera perspective, which provides the audience with a view of all the bodies plotted in the visualization, which is then interpolated to a point which views only the inner solar system orbital paths. A similar technique is used to express the relative differences in size from each body – by providing close up perspectives of each respective body while ensuring the camera includes the Sun and any nearby bodies in the same view. The bodies are also rendered as textured spheres, with each body possessing a texture specific to itself—as well as Saturn and Uranus including an approximation of their rings. The textures, along with the variance in size, aides in distinguishing one body from another.

The orbital paths are also displayed in a fashion that mindfully used the camera perspective to provide the audience with a variety of ways to perceive them. Each planetary body's orbital plane is visited by the camera at angles which are intended to draw out the realization that each orbital plane exists on different planes. The orbital paths themselves are represented in two different ways in the visualization. The first visible rendering of the orbital paths uses a color mapped “tube-like” volume to display the relative speed differences of the body within its own respective orbit. The color mapping maps between red and blue, red denoting faster movement and blue representing slower motion. Labeled colored scales were desired to be included, as this certainly would improve the display, but it was discovered that automating the visibility of varying color scales would imply having to rethink the entire ParaView pipeline for the orbital paths. The camera is positioned in a manner which allows the viewer to examine the speed tube's color variance from a “top-down” perspective. After a few moments the camera then moves downward and the orbital speed tubes gradually fade and are replaced with brightly colored orbital arrows which point in the direction of movement. These arrows are what persist on the visualization after a body has been visited. The visualization uses distinctly different colored arrow glyphs for nearby orbital paths to make distinguishing them easier as the camera travels to other bodies. This approach allows for a single color mapping to be used for all the orbital speed tubes and still provides a way to distinctly represent each orbital path.

The bodies themselves also move along their orbital paths simultaneously with the camera's movement. The movement shows how quickly inner solar system planets move around the Sun relative to outer solar system bodies. The visualization aims to bring an appreciation to this fact by first bringing the audience to the faster orbiting planets, then gradually visiting the next slowest orbiter. By the time the last planet is reached, the visualization hopes to have shown how much longer it takes the outer solar system planets to complete a single orbit—which is also aided by the text overlay which displays the current year on Earth. During the course of the entire animation, Neptune completes only a single orbit.

Appendix A – UNIX Scripting to Obtain and Prepare Data for ParaView

All data for this visualization came from the NASA Jet Propulsion Laboratory (JPL). The JPL group makes a telnet server available to the general public for obtaining Ephemeris data on planets, moons, space craft, and many other objects within our solar system. To build a large dataset using this server, a small toolkit was developed to allow one to obtain ephemeris data for any number of bodies, over whatever period of time (assuming it is available on the JPL server), at a sample rate as fine as 1 minute. The interface to this toolkit is BASH – which accepts a start and end date, sample rate, and a parameter to specify where you would like to save the data. The BASH script then uses a combination of EXPECT scripting, GREP, SED, and CURL to save all of the data in the Horizon JPL format to the specified directory. Once the data has been acquired the script continues to invoke a python process which reads all of the downloaded data, validates the data in a variety of ways (halting and showing detailed error messages if an inconsistency in the data is detected), then generates a series of EnSight Gold data files. These EnSight Gold files are compatible with current versions of ParaView and allow for easy loading of multiple-block, time based, datasets.