

Emulating Laser Facility Operations through a Real-time Collaborative Network

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1. Abstract

Research has been done to support large-scale laser facility operations through the use of semantic data integration, real-time collaborative networking, three-dimensional graphics, and web-based services. Various technologies were utilized in establishing methods of setting up experimental configurations in a visually intuitive manner for experiments that use the Omega lasers. Current technologies have been identified that support scalable tools development to aid in the creation of experimental configuration designs. Virtual environments can be used to examine and collaborate on new or existing configuration requests and provide real-time communication between scientists using the tools. A virtual environment is a simulation of an environment, in this case the OMEGA Target Chamber, on a computer. Users can perform actions such as adding diagnostics in real-time, so researchers may be in different places but interact as if they are in the same room. A three-dimensional virtual model of the OMEGA Target Chamber was created as a platform for user interaction. This interactive model can be used to easily display experimental configurations, and to create campaign proposals from scratch.

2. Introduction

The nature of the Laboratory for Laser Energetics (LLE) is that many scientists collaborate on one project together. Each has a responsibility and carries it out while maintaining clear communication with other researchers. Researchers from around the world use the OMEGA and OMEGA-EP lasers. The idiosyncrasies of the facility and lasers along with the number of scientists involved in any given experiment create difficulties in communication. Furthermore, the compatibility of diagnostics with

experimental configurations, their availability at any given time, and their current working order is not information that researchers have readily available. A program SILOCON (Simulation of Laser Operations through Collaborative Networking) has been written in an attempt to solve this problem.

3. SILOCON

The program SILOCON is based on the creation of a three-dimensional model of the OMEGA target chamber. One feature that distinguishes it from a conventional graphics program is its use of an ontology. An ontology is used in order to find the relationships between researchers, diagnostics, and other items. Ontologies are composed of “subjects” and “predicates”; “subjects” are the objects themselves and “predicates” are the links between all of the subjects [1].

This creates a web of data that can be easily traversed and through which relationships between objects can be used. At LLE, there is an ontology containing information about the ports on the OMEGA laser. For example, for any given port there is a predicate “hasPortID” and “hasAzimuthalAngle.” As shown in Fig. 1, these two predicates link to two subjects, “H_10” and “306,” respectively.

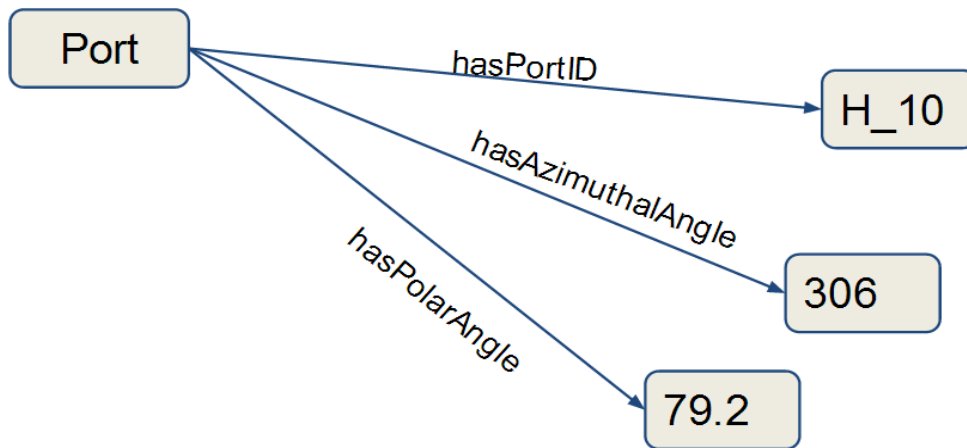


Figure 1: In the ontology, data is represented through connections with other objects. Here, the “port” object has the properties, hasPortID, hasAzimuthalAngle, and hasPolarAngle.

Real time updating and chat capability

SILOCON implements web technologies in order to provide real-time updating among users in a session as well as chat functionality. Researchers can log onto SILOCON and join a “session” with other users. A “session” is an online protocol that allows researchers to share information with each other securely. The session allows multiple different online connections to see update information immediately. For example, if one user in a session moves a diagnostic around the target chamber, the other users in that session will see it move in real-time.

A chat functionality was created in order to facilitate communications among researchers. A list of “contacts” is populated with relevant Principal Investigators (PIs) and facility specialists. Based on the selected experimental configuration, SILOCON searches the ontology to find people who work with the different parts. The “contacts” page then contains the necessary and relevant researchers who may be available to answer the PIs’ questions.

SILOCON creates an interactive environment the PIs can actively use. It differs from

previous attempts to facilitate communication among researchers in that it is not just a forum; its ability to show, create, and manipulate experimental configurations increases its interactivity and allows for clearer communication.

WebGL

WebGL is an integral part of SILOCON; it is used to power the 3D graphics. WebGL is a Javascript API (application programming interface) that uses a computer's graphics card in order to render three-dimensional scenes. WebGL is based on OpenGL, a cross-platform API that uses "shaders" to make 3D graphics. A "shader" is a program that tells the computer how to draw the graphics based on input values. This is where shading takes place in order to create the effect of lighting and shadows [2].

The WebGL rendering process takes several steps, beginning with the input of vertex data into the vertex shader (Fig. 2). The rasterization process then converts 3D points in space to two-dimensional screen locations. These locations are averaged together based on which pixel they are closest to, and they send the averaged color into the fragment shader. In the fragment shader, the color for each pixel is manipulated based on its screen coordinates, cursor location, time, and other variables.

The API "Three.js" was used to facilitate WebGL operations. Since WebGL deals

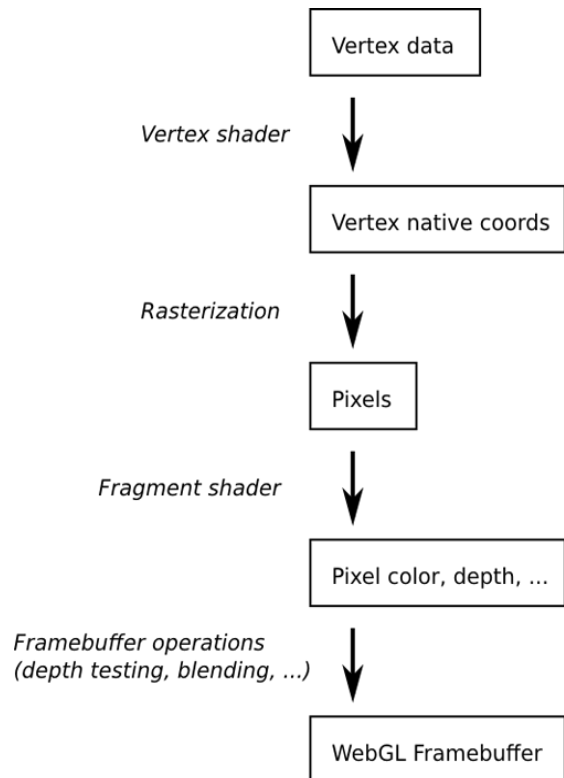


Figure 2: This is the process vertex data must go through in order to be displayed on a computer screen. This is known as the "graphics pipeline."

directly with the hardware of the computer the webpage is running on (the GPU), it lacks user-friendliness despite its robustness. Three.js provides some common functions to make WebGL processes easier. All of the three-dimensional graphics in SILOCON utilize Three.js functions in some way or another [3].

Capabilities of SILOCON

Fig. 3 shows a flattened, two-dimensional version of the OMEGA target chamber. This is currently one of the tools PI's use to plan their experimental configurations. With the model in SILOCON, a three-dimensional, virtual target chamber is projected onto the computer screen and provides an intuitive look at the OMEGA Laser.

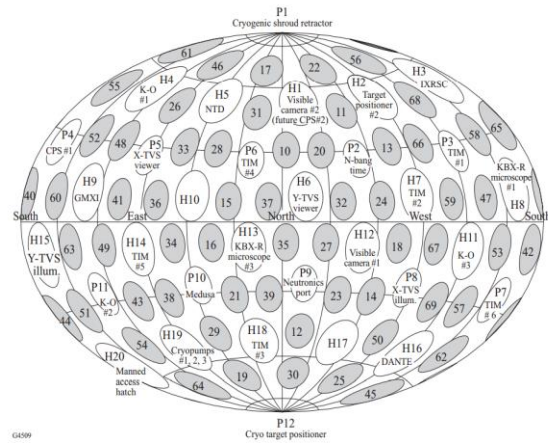


Figure 3: A two-dimensional view of the target chamber.

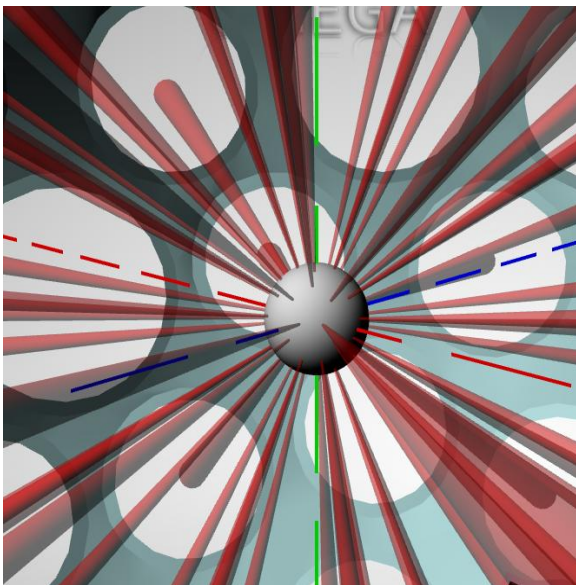


Figure 4: Laser beams converging on a center target (sphere).

Another key feature in SILOCON is its ability to visualize laser projections. In Fig. 4, every laser port is projecting a cone onto the center of the target chamber. These cones' characteristics (such as starting and ending radius) can be manipulated so a realistic representation of the laser beams is shown. SILOCON also has the ability to display dashed lines from any given port to the center of the target chamber as illustrated in Fig. 5. This is helpful for PI's because they can see the lines normal to the ports they are

using.

SILOCON exposes relationships among diagnostics that were previously difficult to see. For example, the user may choose two ports and discover the angle between them. This is possible because the ports, diagnostics, and TIMs (Ten Inch Manipulators) are connected in an ontology.

Ten Inch Manipulators are vacuum containers which can hold and direct certain diagnostics.

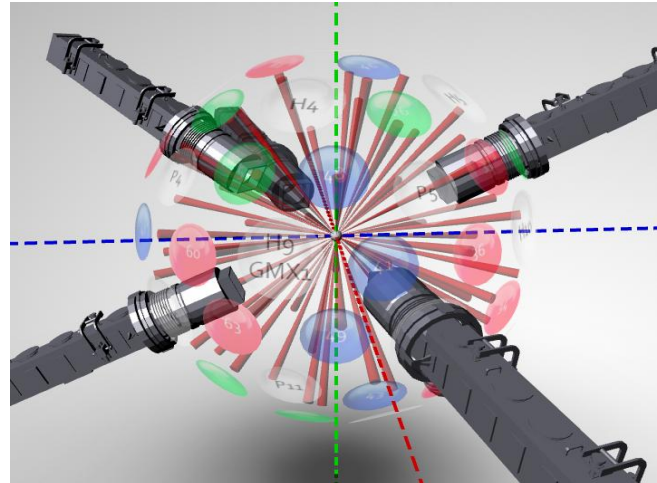


Figure 5: A zoomed out view of the laser beams pointing toward the center of the target chamber.

The ontology contains the positions of each of the ports and subports of the OMEGA laser. SILOCON uses this data to show the PI's relevant information about the ports. For example, one of the most commonly used features for PI's is to find what port is opposite the port of interest. This deceptively simple relationship is not obvious unless the researcher has a physical model of the OMEGA laser.

Visualization of errors

Currently, errors in experimental configurations are detected very late in the configuration process. Since the process for submitting a shot has many steps to it, problems with the setup might not be discovered until the appropriate person sees the experimental configuration and finds the error. Such errors can be scheduling conflicts or configuration conflicts. Because each diagnostic is not always available due to maintenance, it is helpful for the PI's to know which diagnostics they have at their disposal. But since these scheduling conflicts aren't discovered until late in the experimental planning process, PI's might have to

change their whole configurations late in the experimental planning process.

One of the key features of SILOCON is that it provides real-time feedback for errors it has detected. Because SILOCON utilizes an ontology that contains information about each diagnostic, it can find errors in experimental configurations immediately after the errors have been made. An example of a SILOCON error display is shown in Fig. 6.

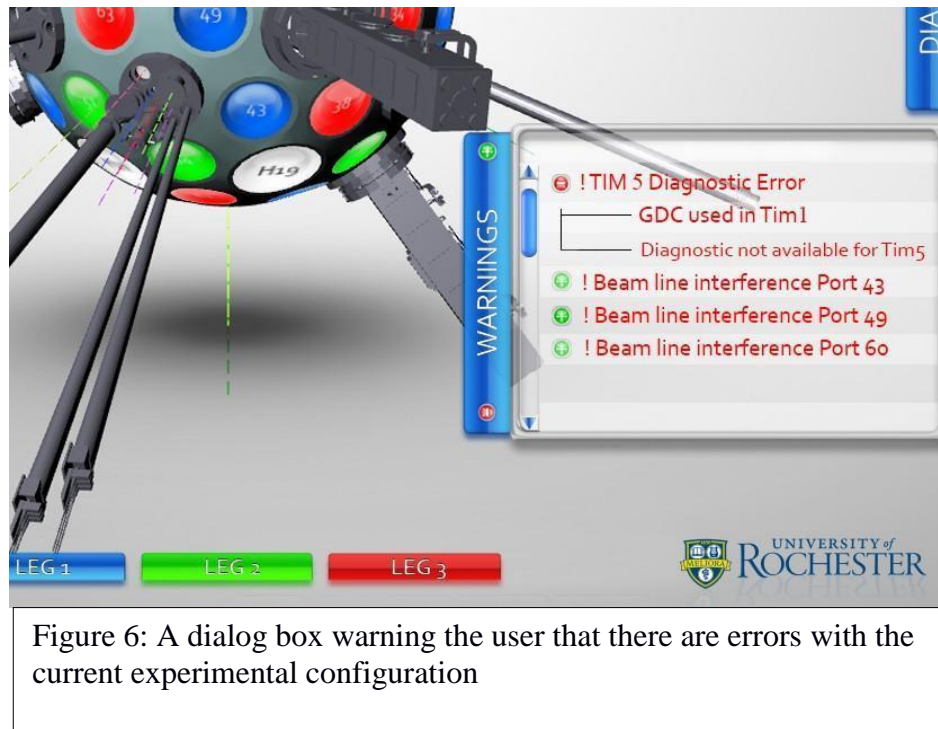


Figure 6: A dialog box warning the user that there are errors with the current experimental configuration

4. Future Work

SILOCON is still being added to and worked on. In order for it to become a full-fledged and useful tool for PI's, it needs to have functionality to load configurations from Shot Request Forms (SRFs) or PI Proposal Templates. This would be the first step in allowing PI's to visualize legacy experimental configurations. Also, the functionality to store information into the OMEGA database needs to be added to SILOCON. This is the database which currently stores all of the information on diagnostics, TIMs, etc.; the ontology is a relational mapping of this database.

This way, when a PI opens up the configuration into SILOCON, he or she may save it back in the database after manipulating data.

5. Conclusion

This research demonstrates that tools like SILOCON can be useful in the LLE work environment. The key differences between SILOCON and a typical, static, forum-based tool are its versatile functionality, three-dimensional capabilities, and dynamic error-detection functionality. A forum-based tool, or a website with a strict, question-and-answer layout, lacks the versatility and communication options SILOCON provides. Future work will make SILOCON an extremely useful and integral part of the LLE facility.

6. References

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7. Acknowledgments

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