X-Ray Window: Portable Visualization on the International Space Station

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1 Introduction

The "X-Ray Window" application is being explored at NASA's Johnson Space Center as part of a suite of graphical applications for use on the International Space Station (ISS). With this application, ISS crewmembers will utilize graphical tablets and/or augmented reality eyewear to "see through" the walls of their station module to the interiors of other modules and to the exterior of the station itself.

Potentially, this application will be used to facilitate ISS crewmembers in their efforts to locate stowed objects on the station and, even more importantly (according to recent ISS crew debriefings), to locate empty stowage space. Crewmembers will be able to access gauge readings from equipment throughout the station, as well as telemetry data from outside the ISS. They will also be able to monitor the progress of extra-vehicular activities being performed by astronauts, and even shuttle docking procedures.

2 Motion Tracking

There are three primary aspects to the development of this application. First, X-Ray Window must determine the display device's current position and orientation. There have been several motion tracking technologies developed in recent years (mainly for VR applications) that could help here [Welch and Foxlin 2002], but they have not been effectively applied within sensitive environments like the International Space Station. Many of these technologies (e.g., electromagnetic and optical approaches) cannot be applied within the confines of the ISS, due to the interference that they would produce with existing communication transmissions within the station. Others (e.g., acoustic and mechanical) are impractical due to their need for an uncluttered environment that does not correspond to the realities of the station.

To overcome these difficulties, two of the newer technological means of pinpointing position and orientation within a tracked environment are being investigated. The recent development of commercially available chips containing accelerometers and gyroscopes have resulted in a mechanism for establishing inertial motion tracking on board the ISS in a manner that will not interfere with existing station functionality and that does not require a pristine, line-of-sight setting to be successful.

In addition, recent advances in ultra-wideband (UWB) wireless communication have produced a technology that appears to be capable of supporting discrete spread-spectrum radio communication that would yield only noise-level signals to other transmission receivers on the station and, consequently, would not interfere with those existing transmissions.

Furthermore, UWB research has produced the means to utilize this type of communication to implement indoor radar in numerous transmission-sensitive settings that could be extended to use on the ISS. This produces a means for scanning for objects on board the station without relying upon the comparatively static locator mechanisms that are dependent upon on-board database management.

3 Database Management

X-Ray Window's second development aspect involves the determination of what station features exist in the designated direction in which the display device is pointed. The application could use a database containing module and stowage specifications, along with other information that is available and needed, but it might be more useful to employ image processing and pattern recognition algorithms to actually scan the display device's vicinity in the designated direction (using the aforementioned UWB technology) and catalog everything that currently resides there.

Unfortunately, the ISS data that will need to be accessed by the X-Ray Window application has not been formatted in a standardized manner. Stowage data is largely contained in the Inventory Management System (IMS), but the dynamic nature of some of the stowed items and the reliance of this system on consistent bar-code reader use by the ISS crewmembers calls into question the completeness and accuracy of this database. NASA's Internal Volume Configuration Working Group has established a CAD-based database for the stowage compartments within each ISS module. Equipment readings and telemetry data are, of course, formatted in their own distinctive manners. Part of the challenge of the X-Ray Window project will be to determine what basic data from these various sources is required for the graphical interface, and how that data can be retrieved and, if necessary, reformatted for output to the X-Ray Window display device.

4 GUI & 3D Graphics Display

Finally, the third aspect of the X-Ray Window project is the graphical rendering of the previous information in a coherent manner on the display device. Problems in this area include enabling the crewmember to focus on a particular ISS module by adjusting the depth at which the "X-Ray" scan is taking place, handling occlusion of relevant features due to the crowded nature of the ISS contents, and highlighting and labeling objects of potential interest so that sought items can be easily discerned. A primitive prototype of such an interface has been developed.

Acknowledgements

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References

WELCH, G. AND FOXLIN, E. 2002. Motion Tracking: No Silver Bullet, but a Respectable Arsenal. *IEEE Computer Graphics and Applications 22*, 6, pages 24-38.

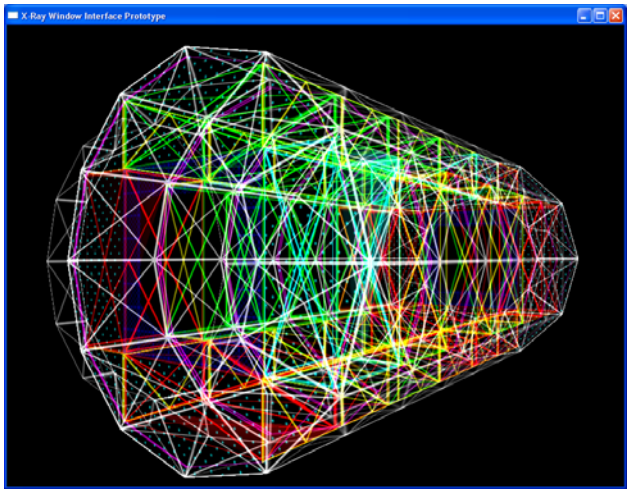

Figure 1. X-Ray Window Rendering of ISS *Destiny* Module, with Color-Coded Stowage and Equipment Components