SPHERES VERTIGO Program: Vision Based Navigation Research onboard the International Space Station

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The Synchronize Position Hold Engage Reorient Experiemental Satellites (SPHERES) have been operating within the interior of the International Space Station (ISS), since they were launched in 2006. They have performed 23 crew-interactive test sessions that have developed and matured different areas of satellite formation flight such as rendezvous and docking, collision avoidance, reconfiguration and assembly and relative navigation[1], [2]. The SPHERES Satellites are shown in Figure 2, where they are about to dock to each other.

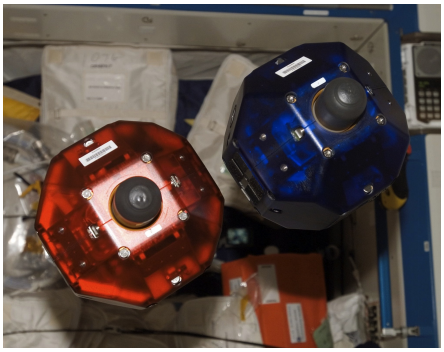

Fig. 1. SPHERES Satellites about to dock onboard the ISS (NASA)

In 2009, a research program was completed by the MIT Space Systems Laboratory and Aurora Flight Sciences to design and build a "flight-qualifiable" upgrade to the SPHERES Satellites that is capable of performing Computer Vision Based Navigation with the SPHERES Satellites. This program was performed for the US Naval Research Laboratory as part of the Low Impact Inspection Vehicle (LIIVe) program, which is intended to develop robotic inspection spacecraft that can be easily placed on large, high value satellites[3].

Fig. 2. SPHERES Satellites with Astronauts onboard ISS (NASA)

As a result, the SPHERES Goggles were developed and upgraded the satellites to include two cameras, an upgraded x86 processor running Linux, an 802.11 communications system and an onboard power system[4], [5]. Research was performed using this system on fiducial based relative navigation and the proposed Mars Sample Return mission's orbital rendezvous and capture.

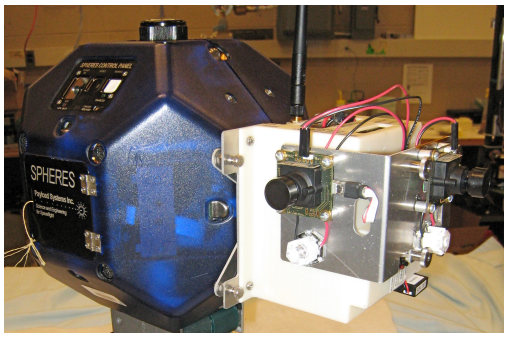

Fig. 3. SPHERES Goggles developed under the LIIVe Program

In 2010, DARPA released a BAA for performing Vision Based Navigation research onboard the ISS. MIT and Aurora Flight Sciences proposed to launch an flight-qualified version of the Goggles developed under the LIIVe program. This proposal was selected, and the hardware, algorithms, software and operational procedures are currently under development. Preliminary image processing results of the visual navigation algorithms are shown in Figure 4. This hardware upgrade is being manifested for launch in early 2012.

Fig. 4. Initial Image Processing Outputs from the SPHERES Goggles

This talk will present an overview of the SPHERES satellites and their capabilities and current achievements. It will discuss the Goggles design that was developed during the LIIVe program and highlight the lessons learned. The talk will give an overview of the VERTIGO program and deliverables. It will discuss the status and current progress towards a 2012 launch.

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