SPACE MANEUVERS SIMULATOR (SMS)

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Abstract

Orbit control missions have been discussed worldwide for many years, and various missions have been carried out, such as docking spacecraft to the space station or guiding the spacecraft to the moon, Mars, and other planets. Many of these missions have been conducted manually, and some are entirely autonomous. Due to the need for Control algorithms validation for this kind of mission, Space Research Lab designed and developed a novel architecture 3DOF Simulator for testing the Rendevouz, docking, and Space Maneuvers algorithm. After complete research, we examined different testbeds used worldwide, and considering the existing conditions, a new architecture has been proposed, designed, and manufactured.

Introduction

For testing the missions software and control algorithms, it is necessary to provide a testbed platform that can simulate the satellite's center of mass movement in two or three planer dimensions by creating suspension conditions. Test platforms have been created in the most sophisticated type, ranging from robotic arms that move with high degrees of freedom to existing simulators of two degrees of freedom. We designed a testbed by using commercial components with the following details is proposed. We set a goal to design and build a testbed with 2 DOF planer motions in the X and Y axis (if we assume the Z-axis is the normal axis to the ground). We will simulate docking and rendezvous of the satellite, so we do not need freedom on Z-axis.

Design

After investigating the different types of testbeds, we approach an architecture that combines two concepts, quadcopter, and hovercraft. Due to our project's goals, constraints, and requirements, we need a system that has to be stable and has no torque forces in the standby mode. So we need to eliminate the rotary part's torque and, on the other hand, the friction between the ground and testbed.

Hover crafts are the most valuable machines used in different applications. Their main concepts are the reduction of ground friction for floating the vehicle on several surfaces. The Final architecture designed in Solidworks shown in Fig 1.

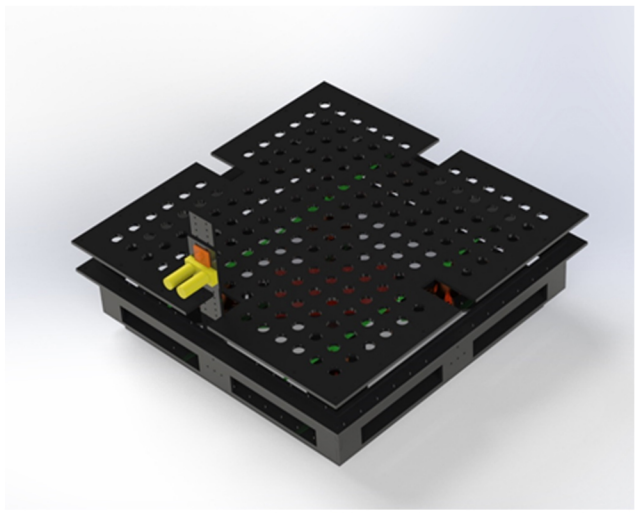

Fig1 - SMS 3D Design

We have four main brushless motors that rotate in the opposite direction to eliminate each motor torque. A plastic skirt to produce the suspension condition. A special Camera and LIDAR as our primary sensors. The mainboard is Raspberry Pi that allows us to process lots of data and make commands. Last but least, a 16 Ah Battery that provides us 6 to 10 min test duration. The arrangement of parts is shown in Fig2.

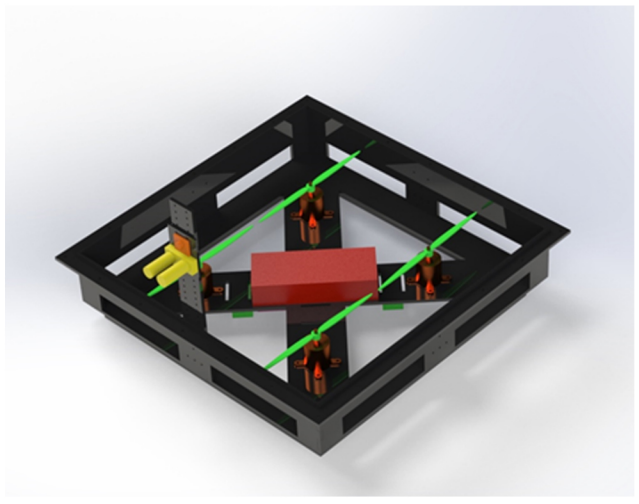

Fig2 - SMS The arrangement of parts

The dimensions of the SMS is 490 * 490 * 155 mm (without considering the base of the camera). It weighs 4626.5 grams and the position of the center of mass in the system is at the bottom and close to the surface, which will provide static and dynamic stability of the system. it shown in the Fig 3. In the structural design of the device, for simpler and more accurate assembly, the parts are designed in a puzzle form, as shown in Fig 4, which greatly simplifies the assembly of the structure.

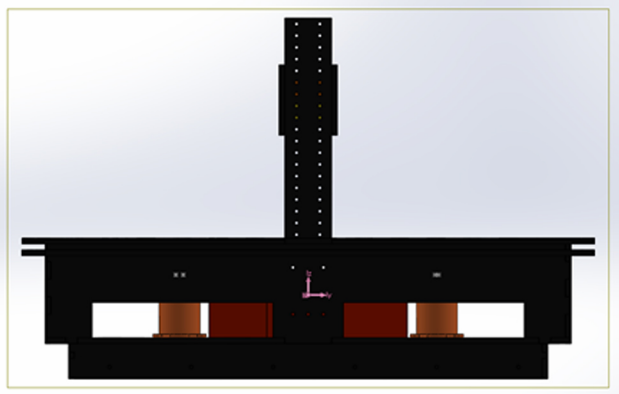

Fig 3 - SMS Center of Mass Position

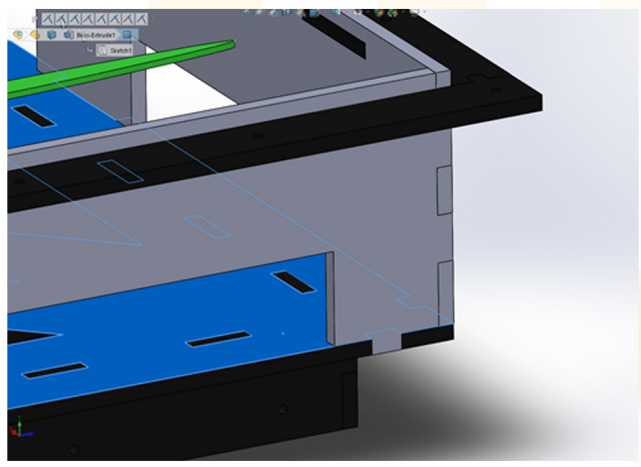

Fig 4 - SMS Puzzle form Structure

Assembly

After completation of designing process we started to assembling the SMS structure and installing the equipments Fig 5 (without camera and LIDAR). Then we made different test to verify the performance of the suspension and dynamic condition. Finally SMS Compeletly satisfied all requirments of the

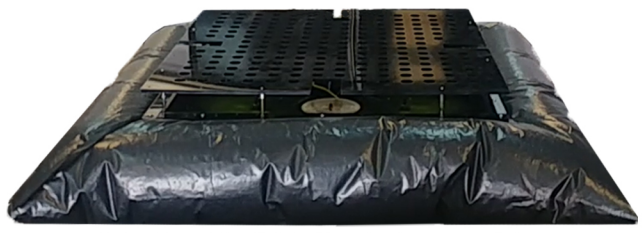

Fig5 - SMS Final Assembly

Conclusion

This study explained the designing, developing, and construction of a 3DOF testbed to simulate satellite motion (2 degrees planar) and attitude (1 degree about Yaw). By selecting a suitable Architecture that satisfied the project's system requirements, we chose a combination of hovercraft and quadcopter. SMS makes the opportunities to examine, test, and validate the Space Maneuvers algorithm for students and space industries.