National Aeronautics and Space Administration

Space RACE*

Capturing an Orbiting Sample and a Nation's Imagination

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Background

A proposed architecture for future planetary sample return missions would consist of capturing on-orbit a sample container (collected from the surface of a planetary body and launched into space) and transferring the sample container into an earth return/reentry capsule. A challenge to this proposed architecture is integrating space applicable sensor technologies with sufficient capturing devices. While useful technologies on Earth, Earth-related rendezvous/capture technologies, such as magnetic field sensors, sound-based sensors, and Earth orbit-based radios like GPS, are not applicable to space. Inspired by the in-orbit sample capture challenge, NASA JPL has designed the Space Rendezvous And Capture Experiment (Space RACE). During this project, we would conduct a proof of concept of the Space RACE challenge by designing a small mobile robot platform traversing along a velodrome track to detect/capture a mock-up orbiting sample moving along the same track. The Space RACE challenge would inspire technologists to help deliver solutions to the on-orbit sample capture task by facilitating an exciting racing environment in order to foster the required innovation for such a critical challenge.

Design Objective

Design an autonomous robot that could capture a 10 cm, 0.5 kg sphere (Orbiting Sample, OS) traversing around a velodrome track at 5 m/s.

Criteria and Constraints

- Robot must maintain contact with the ground.
- Robot must maintain a minimum forward velocity of 4-5m/s.
- Robot may extend its workspace beyond starting configuration by 1m in height direction and 1m either in the forward/backward direction.
- Robot may not employ any technology not applicable to space rendezvous/capture operations.
- Robot may not exceed 50 kg.
- Robot may not exceed 0.75m width X 1m length X 1m height in its starting configuration.
- Robot OS-capturing device may not exceed 30cm in diameter.
- Max speed 10m/s.

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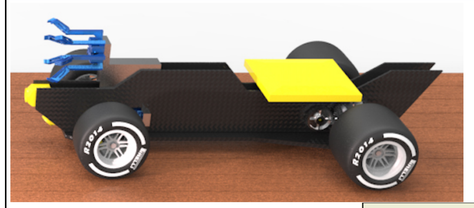
Design Summary

The team is tasked with designing and building a chaser robot that would meet the Space RACE competition rules. The robot platform would be an 1/5 scale electric buggy ready to run remote control kit. The robot would utilize two cameras to navigate the track. The first camera would be used to track the orbit line and the second camera, installed with a bandpass filter, would track the OS. The capturing device would consist of a one degree of freedom gripping claw. Two infrared proximity sensors would be mounted inside the claw to detect the ball inside the claw and initiate the capture sequence. When the capture sequence begins, a linear actuator would cause the capture claw to close its grippers. An Intel Next Unit of Computer (NUC) and Teensy 3.1 Microcontroller would be used to monitor and control the robot.

Design

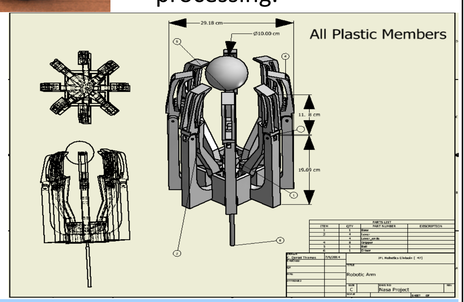


Chaser Robot

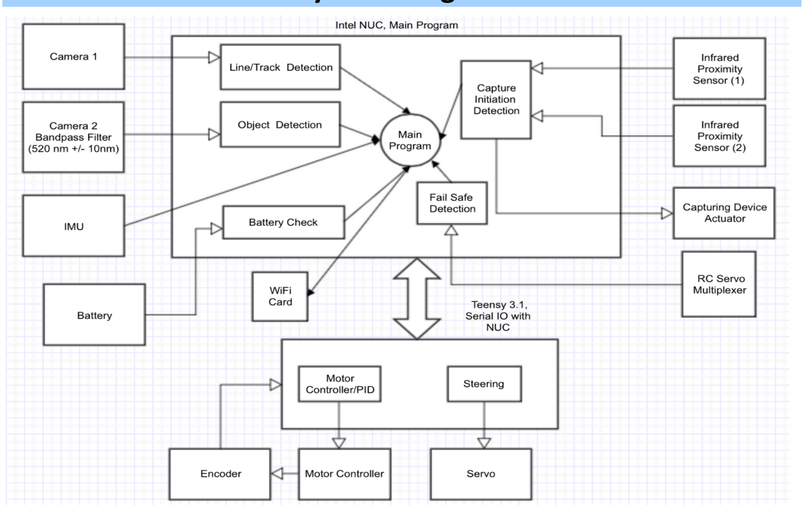
- 1/5 Electric Buggy RC Kit
- Capture device mounted in front of the robot.
- 2 Cameras for Image processing.

Capture Device

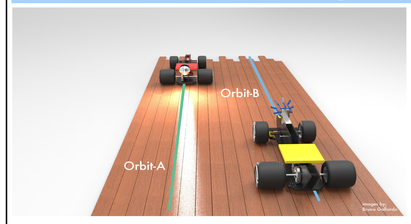
- 1 Degree of Freedom gripping claw.
- 2 proximity sensors mounted inside claw to initiate capture sequence.
- Gripping motion performed by an actuator.



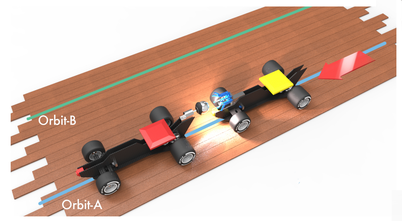
System Diagram



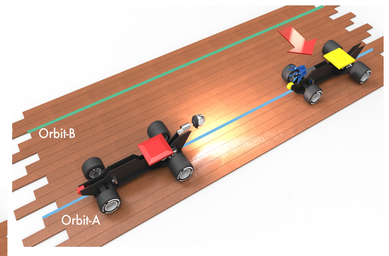
Concept of Operations



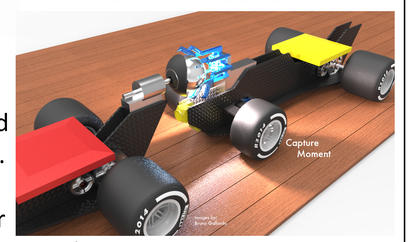
- Chaser Robot would utilize camera 2 with a green bandpass filter (520 nm ± 10 nm) to locate OS.
- When OS is located within 25 m, the Chaser Robot would change orbit and navigate via the OS.



- OS Robot would start on Orbit A and moves at a constant velocity of 5 m/s, utilizing an infrared line detector to follow the track.
- Chaser Robot would start on Orbit B at an initial velocity of 5 m/s, utilizing camera 1 to follow track line.

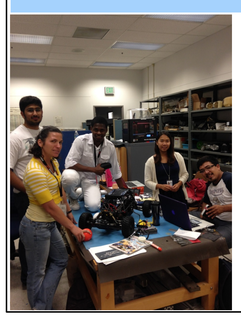


- Chaser Robot would reduce the gap between platforms maintaining centerline of the OS within ± 10 cm.



- When the OS is at least 6 cm inside of the capturing device, infrared proximity sensor would initiate the capturing sequence.
- The capturing sequence would activate a linear actuator closing the grippers on the capturing device.
- Once the grippers are closed, the Chaser Robot would reduce speed to 4 m/s and pull the OS away from the OS Robot.

Conclusions



The team has four weeks remaining, out of a ten week internship, to build and test the chaser robot. Final testing would be conducted at the VELO Sports Center in Carson, CA. In addition to building the chaser robot, the team will also be designing and building the Orbiting Sample robot.

*Concept only – Pre-decisional – for Planning and Discussion Purposes Only