Mobility System and Gait For Microgravity Environments

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ASTEROIDS

Motivation

The study of small bodies, such as asteroids, is a field that's full potential is yet to be uncovered. Missions have been done to recover samples from these small bodies to study their composition and origin, such as the OSIRIS-REx Spacecraft, but the ability to traverse on these microgravity environments has yet to be accomplished.

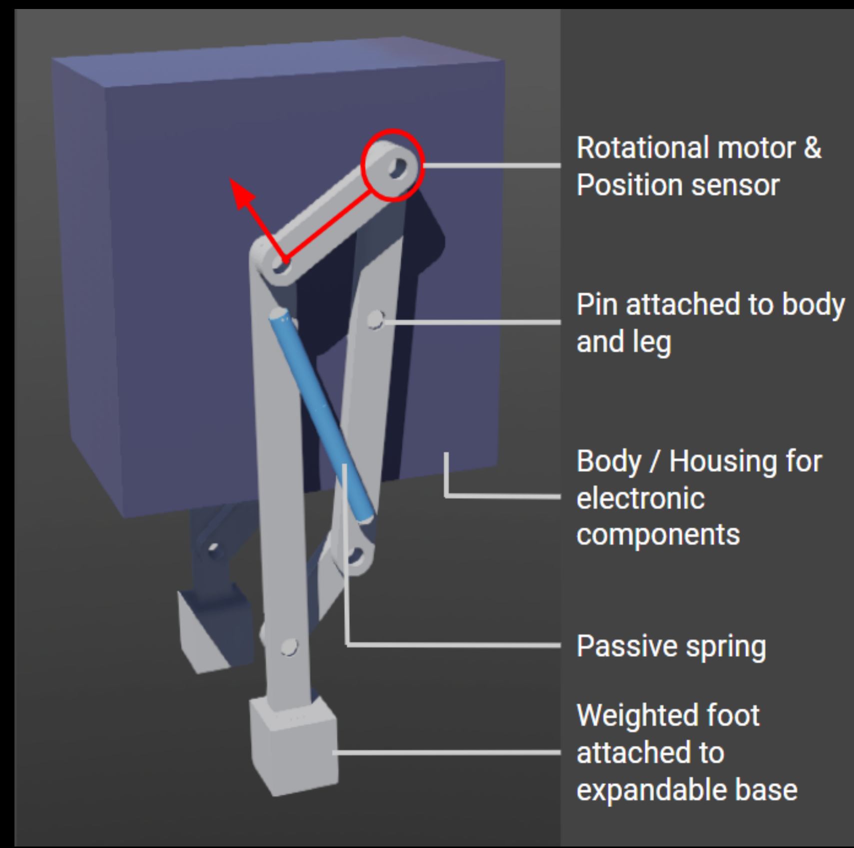
Figure 1: OSIRIS-REx spacecraft pictured touching down and grabbing sample from he surface of Bennu.

Objective

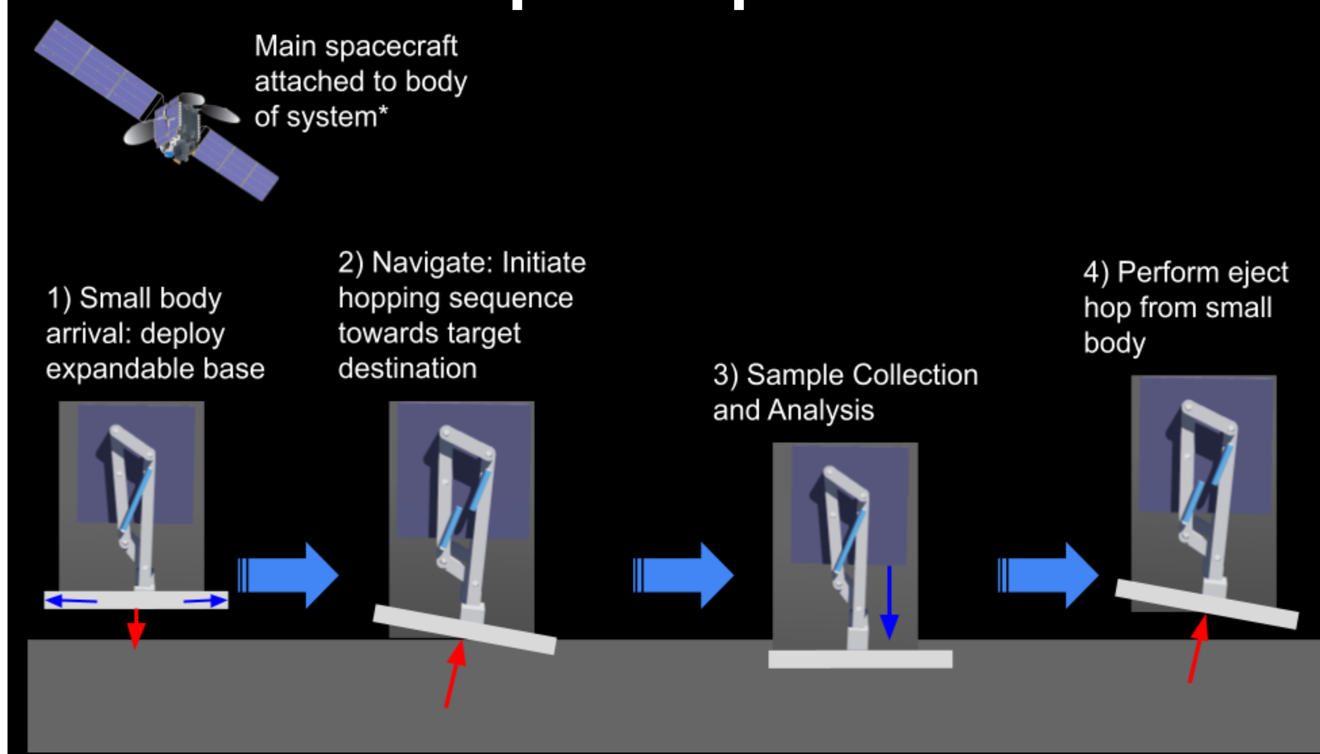
Design an optimal mobility system and gait capable of navigating in microgravity environments to elongate analysis and sample collection process done on small bodies such as Deimos.

Figure 2: Photograph of Deimos; possible destination for movement system's implementation.

Mobility System Concept Model



Concept of Operations



Functionality

The movement mechanism's design is focused specifically on performing hops, based on the design of a prismatic spring leg biped and the possible implementation of inflatable components. The plan is to have a soft landing and perform a series lunges toward the planned site in the form of "mini-hops."

Hopping Gait

Utilizing a rotational motor and position sensor on each spring leg, the attitude of the system is planned to be controlled by actuating a jerk-like movement on the top segment of the spring leg to lift the leg up and perform a hop in the corresponding time and location based on the surface's terrain.

Spring Leg

Utilizing a four-bar system and a passive spring running through the vertical rods, the prismatic passive spring leg was created in the simulation program Webots, with the purpose of being the ideal design for performing hops in a microgravity environment.

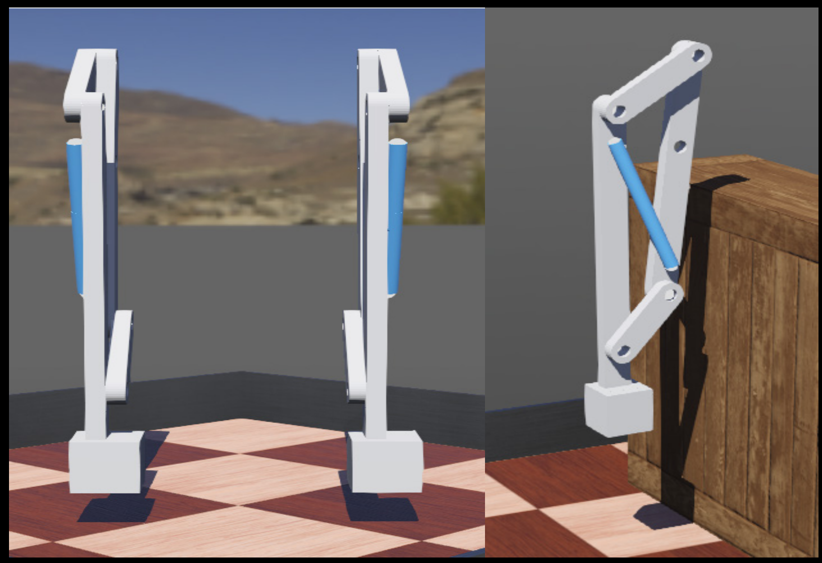


Figure 4. four bar spring leg system modeled in simulation program Webots.

Approach

For experimentation, the plan is to conduct self-learning tests where the movement system adapts to the body's surface and conditions to obtain an optimal movement gait through the process of iterations. Due to the low traction and gravitational acceleration, the ideal gait is that of hopping and leg design approach takes inspiration from ETH Zurichs quadruped project Spacebok

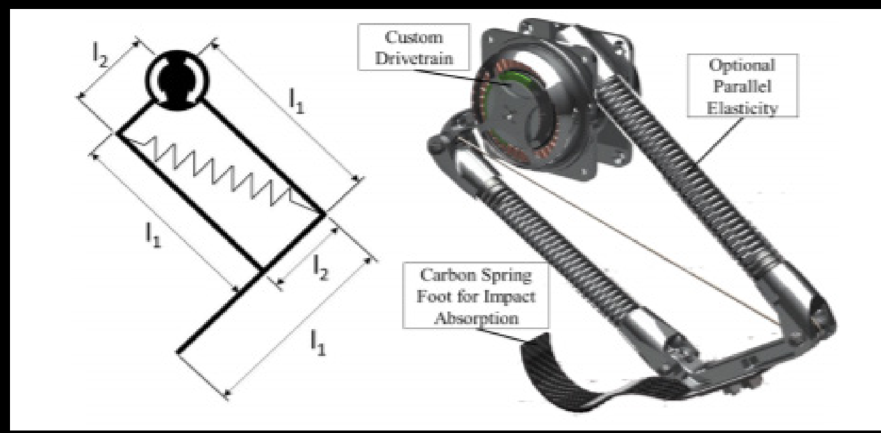


Figure 3. Leg design approach taken based on ETH Zurichs Spacebok Project (Arm et al, 2019, p. 2).

Conclusion

With a passive model of the system being completed utilizing the simulation program Webots, a PID controller based on position and torque control is being developed to optimize the power output of the system to make it as efficient as possible. By testing these designs and integrating evolution-based simulations, we can potentially utilize less power on the movement of the spacecraft and focus its use on other systems. If this approach is effective, it could standardize movement mechanisms on spacecrafts destined to small bodies.