Spherical Mobile Robot for Asteroid Exploration and Defense

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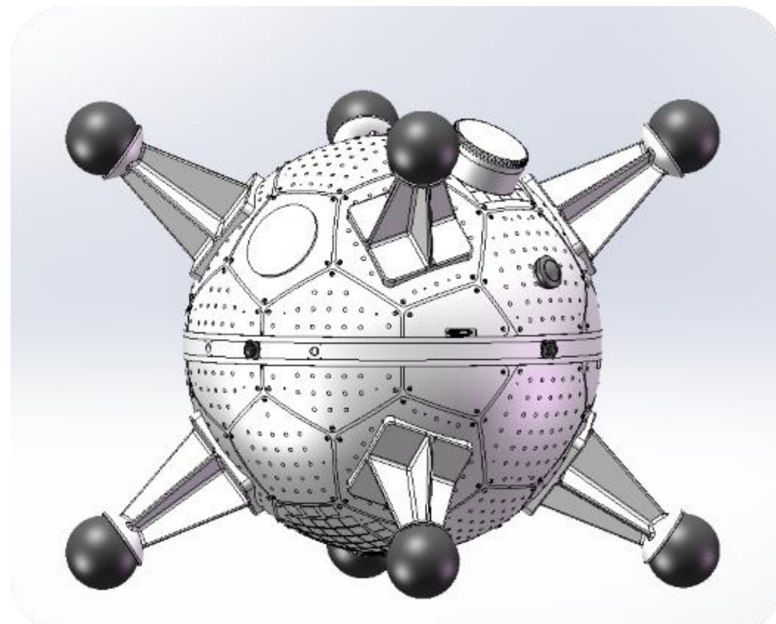
1.Introduction

The asteroid exploration missions not only make contribution to understand the evolution of the solar system and the origin of life, but also provide extremely important material resources for the future long-term large-scale planetary surface exploration, such as the Earth-Moon economic circle. It is of great significance for human beings to carry out asteroid defense and in-situ resource utilization. Mobile robots with relevant payloads are effective means of asteroid surface exploration. However, the gravitational acceleration on the surface of asteroid is 4~5 orders of magnitude smaller than that of the earth. It is difficult for wheeled or tracked mobile robots to attach and move on the surface of asteroids because of microgravity and unknown terrain.

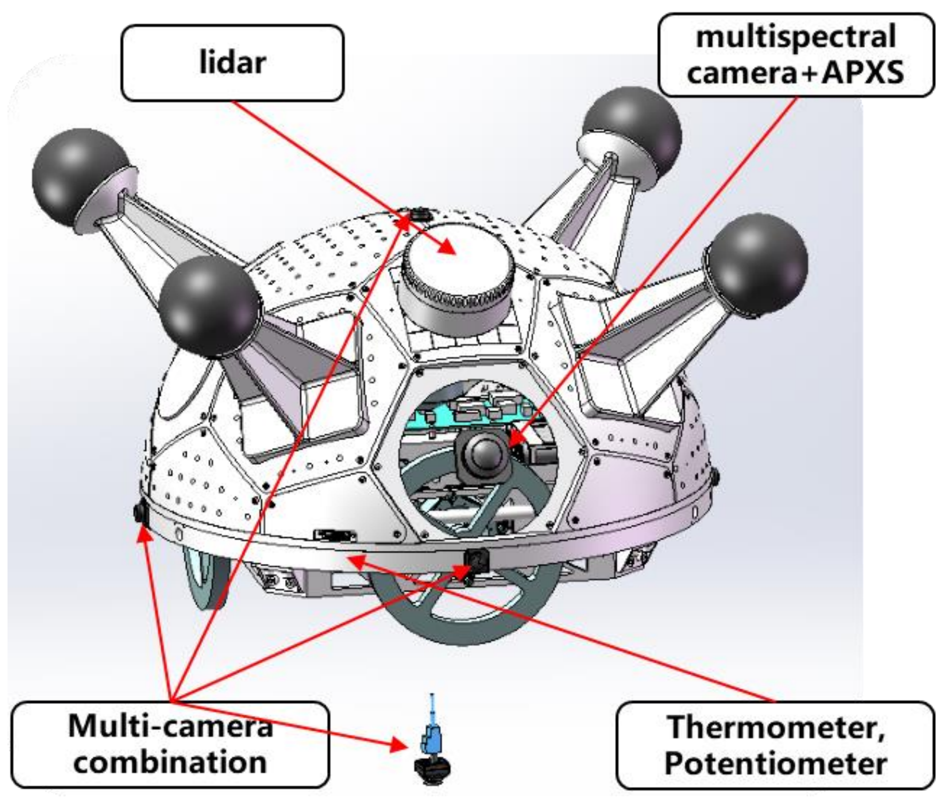
2.Design of spherical mobile asteroid robot

For comprehensive and efficient exploration on the asteroid surface, this paper proposes a spherical mobile asteroid robot (SMART). SMART adopts a spherical structure with 8 fixed leg supports. The symmetrical structure design is beneficial to omnidirectional movement and improve the detection accuracy. The movement of the SMART depends on three orthogonally distributed reaction flywheels. Through the torque vector control of the flywheels, the omnidirectional attitude roll movement of the robot is realized, which effectively solves the problem of microgravity.

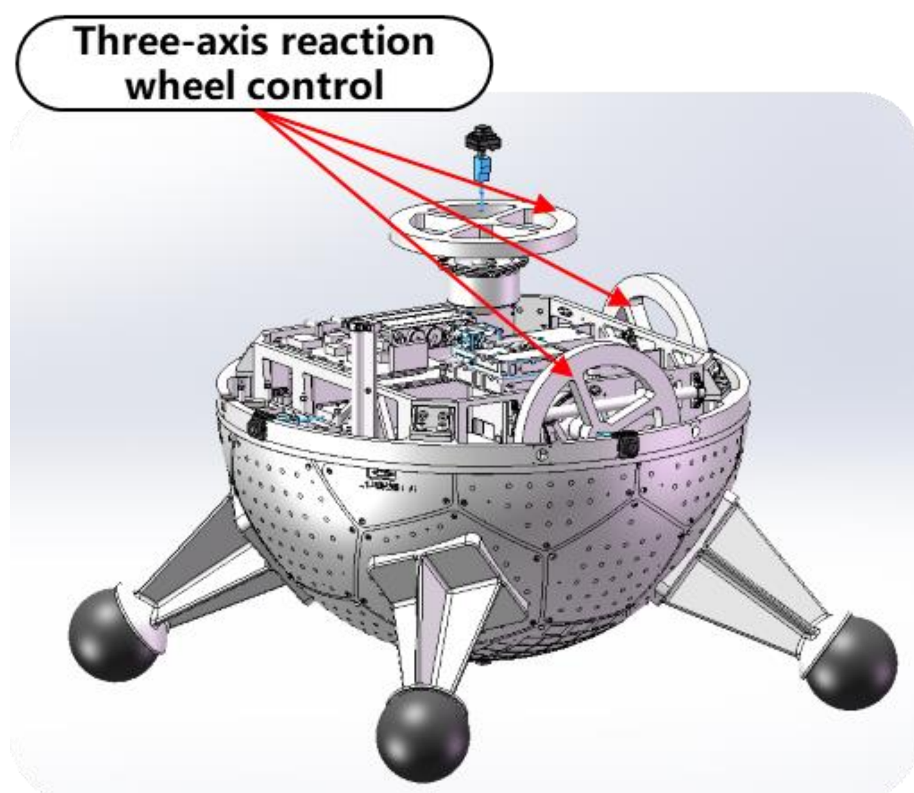


SMART configuration

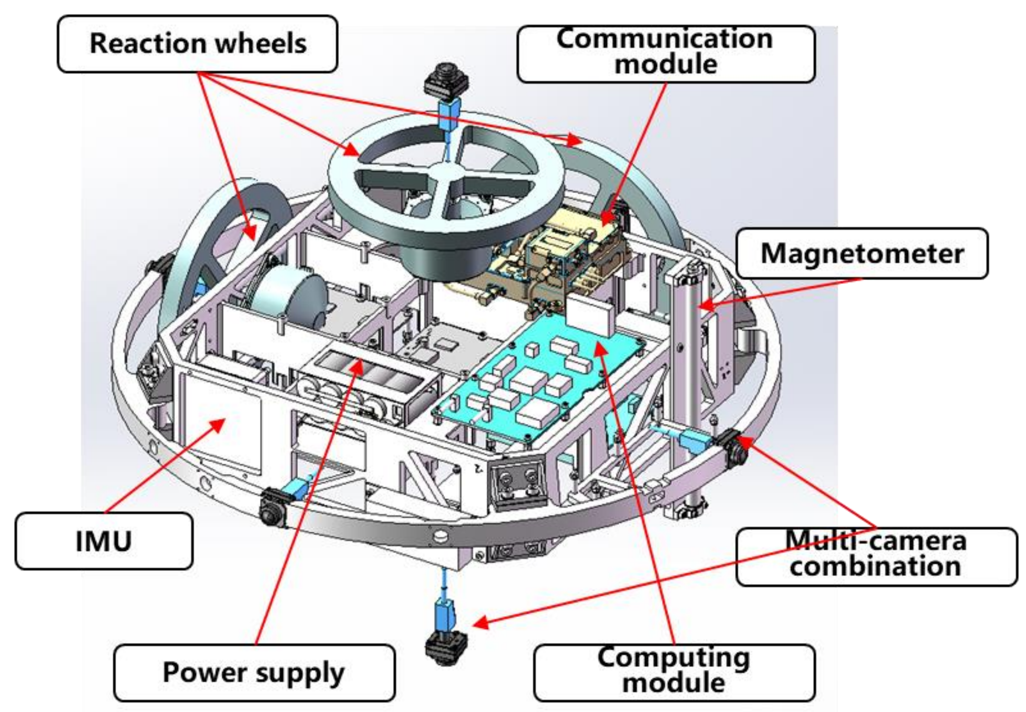
SAMRT adopts a spherical configuration. The diameter is about 200mm and the weight is about 15kg. There are 8 leg supports fixed on the spherical surface of SAMRT. The movement of the SMART depends on three orthogonally distributed reaction wheels. The torque vector of the reaction wheels can control the motion and attitude of the robot at the same time. This drive device will avoid failures caused by splashed soil. The power supply of the robot uses the graphene supercapacitor battery with high current and high reliability. The surface of the robot sphere is attached with solar cells and solar sensors, which can be used for energy supplement and attitude determination. Three optical proximity sensors (OPS) are deployed on the robot surface. They are used to measure the robot's relative orientation to the asteroid ground by the obtained reflecting light. The SAMRT uses the computing module based on an embedded GPU with a 1.3RFLOPS AI computing power.



Payloads



Movement and attitude control by reaction wheels

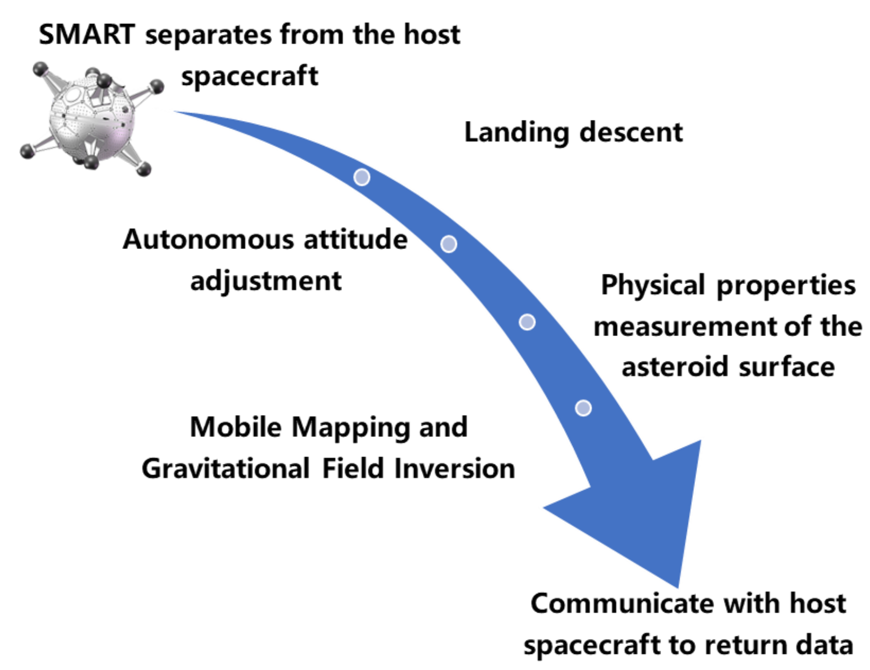


Component distribution

3. Mission objectives

The payloads deployed on SAMRT include multispectral cameras, APXS, lidar, inertial sensors and multiple visible light cameras. There are three main mission objectives of SMART:

(1) On-site exploration of the asteroid surface composition and physical properties.
(2) Asteroid 3D reconstruction and mapping on the asteroid surface.
(3) The inversion of the asteroid surface gravitational field.



The mission plan of SAMRT