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DIGITAL TWIN STUDY OF A CONTROLLED VERTICAL TAKE-OFF AND LANDING MOON ROCKET WITH NEURAL NETWORK INTEGRATION

Abstract

This study focuses on research aimed at the safer and more effective design and control of rocket systems capable of vertical landing and takeoff from a specified altitude. In this context, a digital twin of a robotic lander designed for a lunar descent, equipped with a cold gas propulsion system consisting of 4 main thrusters and 2 RCS thrusters, has been created.

The digital twin replicates the real rocket by incorporating various parameters such as the rocket plant model, atmospheric model, external force model, suspension model, and propulsion model. This enables the digital twin, under conditions closest to reality, to evaluate the rocket's performance and identify potential errors in advance. In the space industry, the production and testing costs of such rockets are generally high. Therefore, digital twins and simulations can help reduce costs by assessing real-world experiences in a virtual environment and testing rockets. This study aims to create a digital twin of a vertically landing rocket to simulate vertical landings under different conditions. This method allows for optimizing the rocket's performance and measuring and inferring unforeseen errors by pre-modeling and validating subsystems even if the system is not yet complete.

In addition, the trajectory for the rocket's descent and how the rocket will track this trajectory must be tested. These tests can only be conducted after the rocket's entire system is prepared, assembled, and finalized. However, with a digital twin, millions of descent scenarios can be tested within minutes. The most suitable descent and ascent navigation can be determined, and the testing of guidance and control algorithms that will guide and control the rocket along this path can be carried out.

Additionally, testing conditions on different planets may not be replicable in the Earth's environment. For instance, experiencing the Lunar gravity or testing orbital mechanics on Earth is not feasible. In such cases, the use of a digital twin provides a significant advantage in avoiding the high costs associated with testing landing environments on extraterrestrial bodies.