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DESIGN, DEVELOPMENT AND TESTING OF AN ELECTRICALLY POWERED ROCKET FOR VERTICAL LANDING OPTIMIZATION.

Abstract

The development of reusable rockets has had a tremendous impact on reducing the cost to space and increasing its accessibility. Private companies and governmental agencies have shown great interest in using reusable rockets to expand human activities in space at a lower price.

The BackOnEarth scientific project was founded in 2019 to familiarize students with the technical challenges associated with landing a rocket vertically. The project, composed of six students from the Ecole Polytechnique, aims to show that a prototype can be built using limited resources and off-the-shelf components within a limited timeframe. The project was organized around a mechanical design team responsible for the structure of the rocket, the electrical system team overseeing the integration of the embedded hardware and a programming team in charge of developing the GNC algorithms.

A prototype of a 50cm-high reusable rocket, weighing 2kg, electrically propelled, fully 3D-printed and controlled using optimal control techniques was built from the ground-up. We followed an iterative and incremental approach, learning from the continuous design and testing of new parts. The use of 3D printers for the structure of the rocket has been essential in the development of the rocket as it has allowed us to easily test alternative designs and improve the different components every week. The need for modular thrust to take-off and land the rocket has made us rule out the use of conventional small-scale solid rocket motors, and for safety and accessibility concerns, we rapidly abandoned the use of small-scale jet turbines. We therefore concentrated our efforts on an electric ducted fan powered by a high density lithium polymer battery. The rocket's orientation and attitude is acquired by a highly precise IMU in conjunction with a LIDAR. The data is then fed to a Raspberry 4 mounted on the rocket and is processed by an optimal control algorithm, in order to adjust the orientation of the Thrust Vectoring Control turning vanes located at the engine nozzle exit. The TVC system is responsible for controlling the angular velocity of the rocket, and is already implemented on missiles such as the MBDA MICA missile system.

The paper presents the trade-off between landing accuracy and power consumption. In order to achieve this, we are undertaking a series of experiments evaluating different energetic strategies by making our rocket fly and land to heights varying from 1m to 10m.