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EXPERIMENTAL VERIFICATION OF THE ALTITUDE STABILISATION CAPABILITY OF A METEOROLOGICAL BALLOON

Abstract

Stratospheric balloons serve as vital tools for atmospheric and astronomical measurements. Recent advances have opened up new possibilities for them, including Earth observation, stratospheric tourism, and telecommunications networks. The key to these developments lies in improved altitude stability, which enables balloons to navigate through layered wind patterns of the stratosphere without requiring any propulsion. By ascending or descending to catch favorable winds, these balloons can hover over areas of interest for extended periods.

These advances have concentrated on super-pressure or zero-pressure balloons. However, the majority of stratospheric balloons used today are latex balloons used for meteorological measurements (approx. 10 000/week, $300 per launch). While these balloons offer excellent vertical data resolution and altitude coverage, their recovery rate is typically low and environmental impacts are significant. Moreover, the envelopes themselves have remained largely unchanged for over a century, and commonly used stabilization methods have not been adapted for them. Experimental methods have been successful in altitude stabilization, but they require significant changes in mission infrastructure making them many times more expensive.

To tackle those challenges, a novel approach was proposed. A lightweight altitude flight stabilization mechanism for meteorological balloons, that could be easily applied globally without requiring significant changes to mission infrastructure, has been developed.

The research team developed a simulation model of a latex stratospheric balloon, which was the base for the development of the altitude stabilization system. Altitude control methods were analyzed and a gas volume control has been chosen. A conceptual mixed control law regulator with a dedicated volume-changing actuator was modeled. The simulation showed that the control algorithm enables stabilization at a set altitude and performs a controlled descent maneuver to reach it. The promising results led to the design of a real-life controller prototype, ground control station, and actuator prototype. During the in-flight experiment, it was shown that the proposed method works comparable to the results obtained in the simulation, and the balloon can stay within the given altitude range. The study also indicated that it allows envelopes to be reused, reducing costs and environmental impact even further.

The potential benefits of this technology are enormous. In addition to scientific and commercial applications, these advances in meteorological balloon technology hold promise for low-cost space technology testing or rapid crisis response. By developing controllable latex stratospheric balloons, we can increase recovery rates, minimize environmental impacts, and transform the field of small stratospheric balloons for years to come.