IAC-24

Dynamics and Control of Smart Boomerangs

Davide Di Santis[a], Eugenio Brusa[a],
Adrian Stoica[b], Marco B. Quadrelli[b], Federico Rossi[b]

[a] *Department of Mechanical and Aerospace Engineering, Politecnico di Torino, Torino, Italy,*
[b] *Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA, 91109-8099 − U.S.A.*

Abstract

Boomerangs are devices historically known for their capability of returning to their thrower after being launched into the air. However, their trajectory is heavily influenced by environmental and initial conditions, with the latter including throwing the boomerang with the correct roll angle and imparting adequate linear and rotational speed. For this reason, in the context of NASA JPL Innovation to Flight project, the idea of introducing smart boomerangs came into play: such unpowered systems would be capable of achieving trajectories impossible to achieve by standard boomerangs, such as a returning trajectory or any desired path in disturbed environments or under uncertain, inaccurate throw conditions. Such devices could also be capable of returning to a thrower that moves after launch; a possible application idea is the release of boomerang probes from planetary balloons to sample the atmosphere of a planetary body.

A simulation tool was developed to predict a boomerang's trajectory, given its design parameters and launch conditions. To further analyze the capabilities of this system, non-linear equations of motion for boomerang flight dynamics have been developed and tested in simulation. The results were validated by comparison with previously published results about boomerang dynamics. The models further allow us to analyze wind effects. A PID controller was then implemented to enable the following of pre-determined desired trajectories, and different mechanisms of autonomously achieving a mid-air trajectory change were compared. Finally, a design solution is proposed to achieve trajectory changes by means of rotating the boomerang's wings, and considerations about the state estimation problem are presented.

In summary, this work expands knowledge about boomerangs by exploring their dynamics and the possibility of controlling their trajectories. The developed model works as an alternative yet complementary tool to experimental tests as it enables gathering essential data about the feasibility of trajectory control and boomerangs' design in time- and cost-effective manners.