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DYNAMICS AND CONTROL OF SMART BOOMERANGS

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. In an attempt to expand the capabilities of classic boomerangs, Adrian Stoica introduced the concept of a 'smart boomerang'. This boomerang adjusts its flight control surfaces or other internal characteristics to achieve much more complex trajectories than those feasible with standard boomerangs. It can even end its flight at a different location from where it was launched, which is useful if it is to be retrieved by a vehicle in motion. On planets with atmospheres, such a smart boomerang could be launched automatically from an atmospheric platform, such as a balloon on Venus or Titan, or from a ground platform, returning to the platform at its new location. Thus, it can perform observations or even sampling. This has some advantages and disadvantages compared to a drone, such as a helicopter. In this paper, we describe a simulation tool 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 the concept of smart 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.