Research Project 2: Optimal Control Based Soft Landing with Path Constraints

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In this project, optimal-control-based soft landing guidance laws with a quadratic cost function and different path constraints were derived. The proposed guidance laws were designed to prevent ground collision and control the approach angle. Initially, a 3D point mass dynamics with a constant gravitational field was employed, and equality line or plane path constraints were used. Optimal solutions to these constrained problems were derived analytically using Pontryagin's Minimum Principle. Subsequently, a more complex problem with a relaxed line inequality path constraint and 2D point mass dynamics with a constant gravitational field was formulated. In the new formulation, the optimal trajectory transitioned from an unconstrained arc to a constrained arc. An optimal-control-based solution to the modified problem was also analytically derived using Pontryagin's Minimum Principle. This guidance law was then used to formulate a simple algorithm for determining an optimal trajectory confined within a triangular region defined by two lines originating from the landing point. The proposed guidance laws and algorithm were then investigated in simulation for various initial conditions and demonstrated satisfaction of the constraints and very good performance. This project is the first step in the derivation of a 3D, analytical, optimal-control-based guidance law with approach angle constraints.

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