

Designing an MPC Controller for a Simplified Rocket Landing Problem

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Abstract—This document is a model and instructions for L^AT_EX. This and the IEEEtran.cls file define the components of your paper [title, text, heads, etc.]. *CRITICAL: Do Not Use Symbols, Special Characters, Footnotes, or Math in Paper Title or Abstract.

Index Terms—component, formatting, style, styling, insert

I. INTRODUCTION

The objective of the assignment is to implement a model-predictive control (MPC) scheme to land a simplified model of a rocket. The problem is fundamentally one of 'controllability', ie $x(0) = x_s \rightarrow x(t_f) = 0$. The assignment gives an abstracted model, we start by rewriting the model as follows:

$$\begin{bmatrix} r_x(k+1) \\ r_y(k+1) \\ r_z(k+1) \\ v_x(k+1) \\ v_y(k+1) \\ v_z(k+1) \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & T & 0 & 0 \\ 0 & 1 & 0 & 0 & T & 0 \\ 0 & 0 & 1 & 0 & 0 & T \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} r_x(k) \\ r_y(k) \\ r_z(k) \\ v_x(k) \\ v_y(k) \\ v_z(k) \end{bmatrix} + \begin{pmatrix} \frac{T^2}{2m} & 0 & 0 \\ 0 & \frac{T^2}{2m} & 0 \\ 0 & 0 & \frac{T^2}{2m} \\ T & 0 & 0 \\ 0 & T & 0 \\ 0 & 0 & T \end{pmatrix} \begin{bmatrix} f_x(k) + w_x \\ f_y(k) + w_y \\ f_z(k) - mg \end{bmatrix} \quad (1)$$

Although we assume the system is reachable, it is important to check for controllability. Through MATLAB: `Rank = rank(ctrb(A, B))` we find the system is controllable, and we can proceed with designing a controller.

II. DESIGN

A. Controller Design

Three separate controllers are considered in this report. The first controller is an unconstrained, two stage MPC. The second controller builds on the first, and introduces both state and input constraints. The third controller further builds on the first two, introducing disturbance rejection. We start by looking at the first controller.

- 1) *Unconstrained:*
- 2) *Constrained:*
- 3) *Disturbance Rejection:*

B. Experiment Setup

First, it is important to state simplifications for Let the starting parameters be as follows:

$$\begin{bmatrix} r_x(0) \\ r_y(0) \\ r_z(0) \\ v_x(0) \\ v_y(0) \\ v_z(0) \end{bmatrix} = \begin{bmatrix} 600 \\ 600 \\ 500 \\ 5 \\ 5 \\ -15 \end{bmatrix} \wedge f_x(0) = f_y(0) = f_z(0) = 0$$

These starting conditions are the limits of what the assignment permits, i.e a maximum starting altitude of 500m, and a maximum lateral distance of 600m.

III. RESULTS

IV. ANALYSIS & DISCUSSION

V. CONCLUSION

VI. EASE OF USE

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Before you begin to format your paper, first write and save the content as a separate text file. Complete all content and organizational editing before formatting. Please note sections ??-?? below for more information on proofreading, spelling and grammar.

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Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, ac, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

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- Use either SI (MKS) or CGS as primary units. (SI units are encouraged.) English units may be used as secondary units (in parentheses). An exception would be the use of English units as identifiers in trade, such as “3.5-inch disk drive”.
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Number equations consecutively. To make your equations more compact, you may use the solidus (/), the exp function, or appropriate exponents. Italicize Roman symbols for quantities and variables, but not Greek symbols. Use a long dash rather than a hyphen for a minus sign. Punctuate equations with commas or periods when they are part of a sentence, as in:

$$a + b = \gamma \quad (2)$$

Be sure that the symbols in your equation have been defined before or immediately following the equation. Use “(??)”, not “Eq. (??)” or “equation (??)”, except at the beginning of a sentence: “Equation (??) is . . .”

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Please use “soft” (e.g., `\eqref{Eq}`) cross references instead of “hard” references (e.g., (1)). That will make it possible to combine sections, add equations, or change the order of figures or citations without having to go through the file line by line.

Please don’t use the `{eqnarray}` equation environment. Use `{align}` or `{IEEEeqnarray}` instead. The `{eqnarray}` environment leaves unsightly spaces around relation symbols.

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- The subscript for the permeability of vacuum μ_0 , and other common scientific constants, is zero with subscript formatting, not a lowercase letter “o”.
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- In your paper title, if the words “that uses” can accurately replace the word “using”, capitalize the “u”; if not, keep using lower-cased.
- Be aware of the different meanings of the homophones “affect” and “effect”, “complement” and “compliment”, “discreet” and “discrete”.
- Do not confuse “impl
- The prefix “non” is not a word it modifies, usually.
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- The abbreviation “i.e.” means “for example” and “e.g.” means “for instance”.

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Component heads identify the sections of your paper and are not to be confused with section heads. Examples include Acknowledgments, References, etc. For these, the correct style to use is “Section Head” for your Figure caption and “Table Title” for your Table title. Run-in heads, such as “Figure 1”, should be used to apply a style (in this case, the “Figure” style) to the text.

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TABLE I
TABLE TYPE STYLES

Table Head	Table Column Head		
	Table column subhead	Subhead	Subhead
copy	More table copy ^a		

^aSample of a Table footnote.

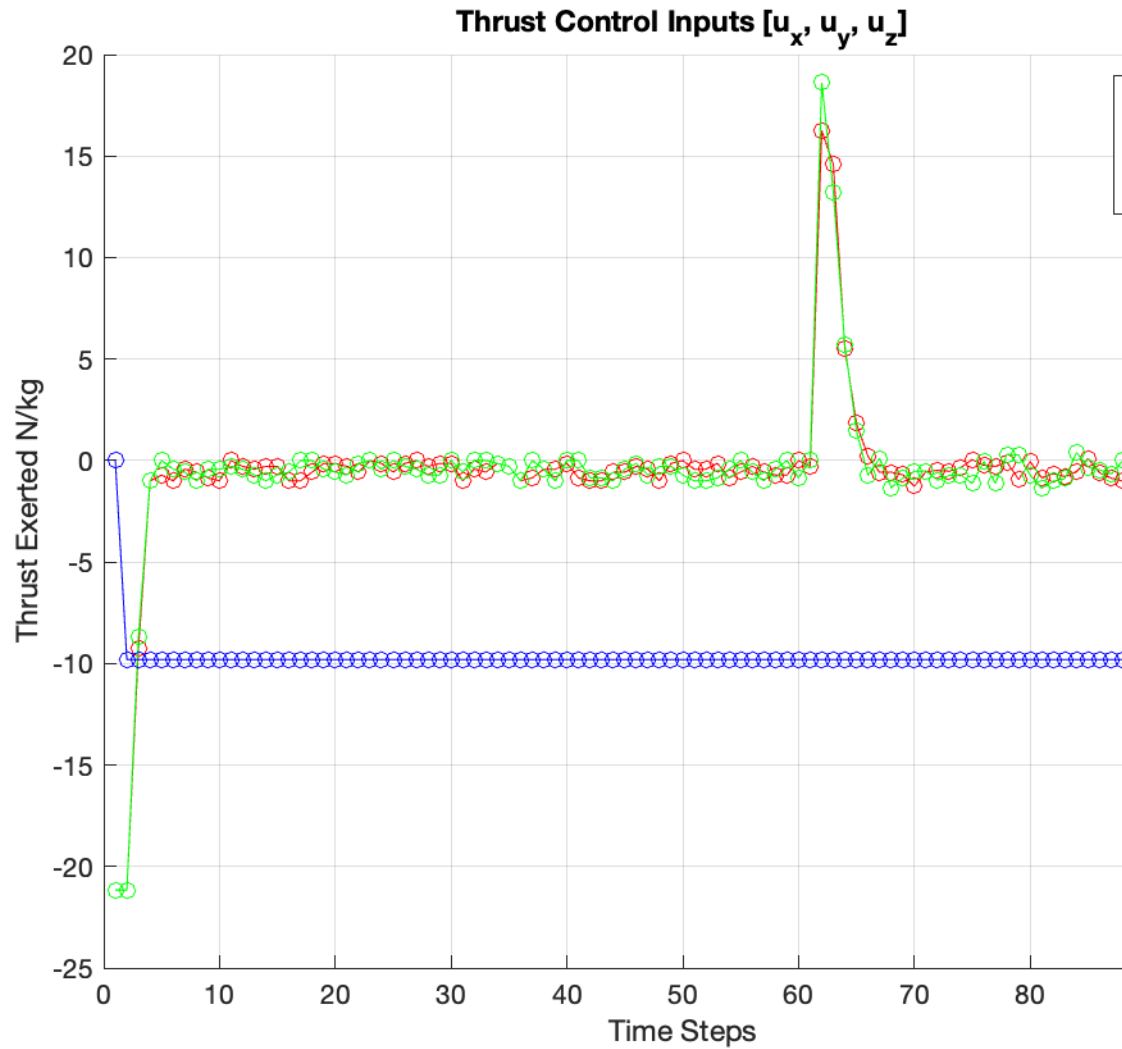


Fig. 1. Example of a figure caption.

figures and tables after they are cited in the text. Use the abbreviation “Fig. ??”, even at the beginning of a sentence.

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ACKNOWLEDGMENT

The preferred spelling of the word “acknowledgment” in America is without an “e” after the “g”. Avoid the stilted expression “one of us (R. B. G.) thanks ...”. Instead, try “R. B. G. thanks...”. Put sponsor acknowledgments in the unnumbered footnote on the first page.

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