Solving Nonlinear Equations of One Variable

by Shankar Kulumani

B.S. in Astronautical Engineering, May 2009, U.S. Air Force Academy
M.S. in Aeronautics and Astronautics, December 2013, Purdue University

A Dissertation submitted to

The Faculty of
The School of Engineering and Applied Science
of The George Washington University
in partial satisfaction of the requirements
for the degree of Doctor of Philosophy

May 28, 2015

Dissertation directed by

Taeyoung Lee
Associate Professor of Mechanical and Aerospace Engineering

The School of Engineering and Applied Science of The George Washington University certifies that Shankar Kulumani has passed the Final Examination for the degree of Doctor of Philosophy as of May 28, 2015. This is the final and approved form of the dissertation.

Solving Nonlinear Equations of One Variable

Shankar Kulumani

Dissertation Research Committee:

Taeyoung Lee, Associate Professor of Engineering and Applied Science,
Dissertation Director

Full Name, Title,
Dissertation Director/Dissertation Co-Director/Committee Member

to Christine

Acknowledgments

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Integer sagittis, sem nec molestie blandit, dui orci fermentum ex, eu vehicula sapien ipsum consectetur lacus. Vivamus non leo ut sem iaculis hendrerit. Duis sed quam ligula. Duis fermentum fringilla ante. Etiam scelerisque mi sapien, ac dictum arcu accumsan et. Fusce vel purus lacinia, rhoncus sapien id, lobortis libero. Vivamus nec odio et felis aliquam eleifend. Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos himenaeos. Curabitur suscipit ex eget purus fermentum, in facilisis mauris viverra. In tincidunt sollicitudin diam, sed volutpat ex vestibulum eget. Curabitur maximus porttitor auctor. Sed imperdiet suscipit leo sed congue. Aliquam porttitor egestas aliquet. Donec imperdiet blandit odio, eu mollis ex bibendum semper. Donec suscipit nisi nisi, nec tempor dolor eleifend a. Aliquam rutrum lacus eget tellus suscipit, et ullamcorper elit eleifend.

Abstract

Solving Nonlinear Equations of One Variable

In mattis lacinia semper. Integer eu purus non felis varius dictum tristique sed leo. Integer gravida rutrum quam. Etiam non posuere nisl. Phasellus laoreet sem eget dui commodo pharetra. Maecenas eget enim tellus. Vivamus rutrum tortor nulla, nec efficitur orci faucibus nec. Nunc nec tempus nulla. Ut dictum, tellus sed fermentum pharetra, arcu nulla pharetra lectus, sit amet volutpat lorem tortor vitae nulla. Interdum et malesuada fames ac ante ipsum primis in faucibus. Vivamus rhoncus fermentum turpis et lacinia. Vestibulum condimentum molestie odio quis blandit. Curabitur a tellus eu ante rutrum finibus eget id libero. Suspendisse euismod pretium pretium. Maecenas congue interdum ante, ut condimentum velit suscipit at. Vestibulum lobortis et orci non maximus.

Table of Contents

List of Figures

List of Tables

List of Abbreviations

CRTBP Circular Restricted Three Body Problem

Preface

Ut ornare ut risus in condimentum. Proin vitae est sit amet eros hendrerit efficitur. Pellentesque ultricies turpis a euismod malesuada. Nam ut ante sollicitudin, blandit erat vel, dignissim purus. Cras molestie luctus dolor non dapibus. Donec ac hendrerit nulla. Vivamus faucibus velit at imperdiet posuere. Suspendisse pharetra sit amet purus id dictum.

Foreword

Fusce in eros a diam molestie fermentum. In nisl neque, egestas at sem at, ornare cursus eros. Aenean euismod erat pretium, sollicitudin leo quis, vestibulum mauris. Proin commodo pharetra aliquam. Aliquam in purus tortor. Nulla viverra neque ac justo fringilla facilisis. Suspendisse et pellentesque sem. Integer laoreet nibh enim, at sollicitudin lectus sodales at. Mauris at vestibulum ex. Sed in sapien in ante sollicitudin ultrices. Pellentesque tincidunt est ut massa vehicula, ac lacinia justo vehicula. Quisque imperdiet feugiat justo a vulputate. Sed non consequat purus, eu pellentesque risus. Phasellus leo felis, eleifend et tincidunt et, commodo non enim.

Prologue

Fusce imperdiet lectus vitae sapien sollicitudin, ac mollis nulla feugiat. Mauris vitae tellus non elit faucibus volutpat. Phasellus congue, urna a luctus dictum, ligula urna commodo ante, at dignissim nunc nulla et ligula. Cras tincidunt, diam et imperdiet vulputate, felis erat malesuada nibh, quis porttitor turpis libero at ligula. Etiam ut lacus euismod, interdum erat eget, lobortis neque. Suspendisse maximus sem in tempor facilisis. Aenean sed quam enim. Mauris posuere libero magna, non posuere nisi luctus vel. Vestibulum porttitor varius nisi, at volutpat ipsum hendrerit nec. In sit amet risus congue, sodales erat in, venenatis tortor. Ut semper placerat nunc, nec laoreet orci egestas aliquet. Phasellus commodo vel mauris eu maximus. Morbi id vulputate nisl.

CHAPTER 1

Introduction

Here's an acronym Circular Restricted Three Body Problem (CRTBP)

1.1 Float environments

Theere are many possible float enviornments, and this section will serve as an introduction and demonstration of each of them. In addition, it offers the ability to ensure that this template actually follows the guidelines.

1.1.1 Figures

Here is a figure as shown in Figure 1.1.

1.1.2 Tables

here's a table in Table 1.1

1.2 References and Citation

1.2.1 Clever referencing

LaTeXoffers the powerful ability to automatically handle references using `\label` and a corresponding `\ref`. While Chapter 1 has more detail on some good practices for LaTeX that I've picked up.

1.2.2 References

We can cite lots of useful papers [1, 2].

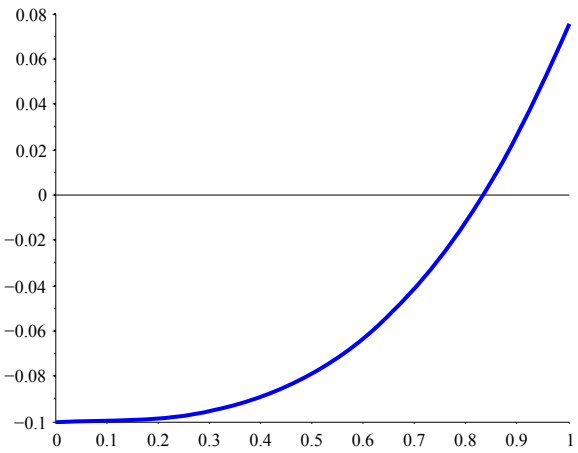

Figure 1.1: Long caption to appear in text

Day	Min Temp	Max Temp	Summary
Monday	11C	22C	A clear day with lots of sunshine. However, the strong breeze will bring down the temperatures.
Tuesday	9C	19C	Cloudy with rain, across many northern regions. Clear spells across most of Scotland and Northern Ireland, but rain reaching the far northwest.
Wednesday	10C	21C	Rain will still linger for the morning. Conditions will improve by early afternoon and continue throughout the evening.

Table 1.1: Long caption for text

1.3 Math

Here are some nice equations Equations (1.1) and (1.2)

$$\min_{s \subset W} \; J(s) = \sum_{i=1}^{l-1} H(s_j, s_{j+1}) \tag{1.1}$$

$$\max_{s \subset W} \; P_{tr}(s) = \prod_{i=1}^{l-1} P_{tr}(s_j, s_{j+1})$$

$$\min_{s \subset W} \; J(s) = \sum_{i=1}^{l-1} H(s_j, s_{j+1}) \tag{1.2}$$

$$\text{subject to } P_{tr}(s) > \epsilon_{tr}$$

CHAPTER 2

Setting

The next chapter has the good stuff.

2.1 Convergence Criteria

Actually, it might have the worst stuff. But it is slightly easier to write than the material in Chapter 1.

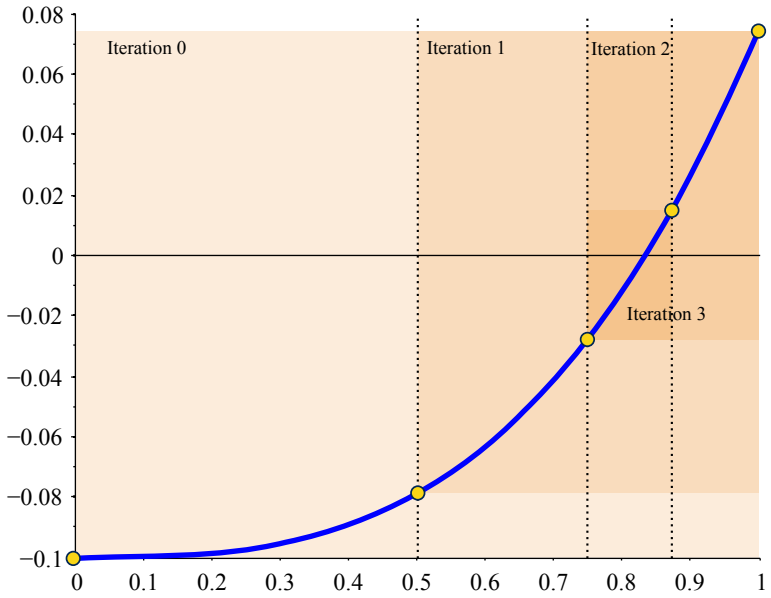

Figure 2.1: Illustration of x- and y-tolerances for bisection iterations

It takes very little text to fill a page in this format, but there is even less text on most of these sample pages.

2.2 Why we are doing it

It is usually a good idea to give reasons for your research. If you do not, the people who paid you to waste all that time will feel really bad about it, and then they will not provide the same opportunity to future students.

I need this page to see what even-numbered pages look like.

Bibliography

[1] Sanjay P Bhat and Dennis S Bernstein. A topological obstruction to continuous global stabilization of rotational motion and the unwinding phenomenon. *Systems & Control Letters*, 2000.

[2] Nalin Chaturvedi, Amit K Sanyal, N Harris McClamroch, et al. Rigid-body attitude control. *Control Systems, IEEE*, 31(3):30–51, 2011.

Appendix A

Methods

Here is how to implement the methods.

A.1 Bisection

The easiest method.

$$x_k = \frac{a_k + b_k}{2} \tag{A.1}$$

A.2 False Position

The next one.

Appendix B

Using Appendices

This appendix contains the portion of the users' manual that describes how to use appendices with this template. It is put in this appendix rather than in Chapter **??** simply so that there are two appendices, so that a list of appendices can appear earlier in the document.

B.1 Starting the Appendices

Actually, using appendices is quite simple. Immediately after the end of the last chapter and before the start of the first appendix, simply enter the command `\appendix`. This will tell LaTeX to change how it interprets the commands `\chapter`, `\section`, *etc.*

Each appendix is actually a chapter, so once the `\appendix` command has been called, start a new appendix by simply using the `\chapter` command.

Note that the `\appendix` command should be called only once–not before the start of each appendix.

B.2 Lists Including the Appendices

As mentioned in Section **??**, the command

must appear in the preamble if there are more than one appendices. For some reason, Rackham does not want the individual appendices and their sections to appear in the Table of Contents, so a special List of Appendices page (which must occur in the Table of Contents!) is required as a sort of extension to the Table of Contents.

This does not require a user of this template to do anything, but it is so silly that I felt it was worth explaining. Also, there is nowhere for the sections or subsections of appendices to show up in the Table of Contents or any of the lists, but they do still create navigation tabs in a modern PDF viewer.