

Geometric Non-Termination Arguments for Integer Programs

Bachelor-Thesis

vorgelegt am: August 6, 2017

**at the Lehr- und Forschungsgebiet Informatik 2
Rheinisch Westfälische Technische Hochschule Aachen**

| | |
|------------------|------------------|
| Name: | Timo Bergerbusch |
| Matrikelnummer: | 344408 |
| Studiengang: | Informatik |
| Studienjahrgang: | 2017 |
| Erstgutachter: | Jera Hensel |
| Zweitgutachter: | Prof. Dr. Noll |

Acknowledgement

First, I would like to thank Prof. Dr. Jürgen Giesl for giving me the opportunity to work on a GER:aktuelle topic.

Secondly I would like to thank Jera Hensel, who supervised me during my thesis. I want to thank her for the many patience answers she gave my no matter how obvious the solution was and encouraging me during the whole process. Also I want to thank her for the possibility to write the underlying program the way I wanted to without any restrictions or limits regarding the way of approaching the topic.

Also I want to thank my girlfriend Nadine Vinkelau and all my friends, who encouraged me during my whole studies and not only accepting that I often was short on time, but also strengthen my back during the whole process. Especially I want to thank my good friend Tobias Räwer, who explained many topics to me over and over again to help me pass my exams without demanding anything in return. Thanks to his selfless behaviour I got this far within 3 years.

Finally I want to thank my parents for giving me the possibility to fulfill my desire to study at a worldwide known university. Without the financial support I would not have had this opportunity.

Erklärung Ich versichere hiermit, dass ich die vorliegende Arbeit selbstständig verfasst und keine anderen als die angegebenen Quellen und Hilfsmittel benutzt sowie Zitate kenntlich gemacht habe.

Aachen, den August 6, 2017

Timo Bergerbusch

Abstract

Contents

| | | |
|----------|--|-----------|
| 1 | Introduction | 3 |
| 2 | Preliminaries | 5 |
| 2.1 | Considered Programs | 5 |
| 2.1.1 | Form | 5 |
| 2.1.2 | Structure | 5 |
| 2.2 | The Theorem | 5 |
| 2.3 | Reverse-Polish-Notation-Tree | 5 |
| 2.4 | <i>SMT</i> -Problem | 5 |
| 3 | Geometric Non-Termination | 7 |
| 3.1 | Derivation of the <i>STEM</i> | 7 |
| 3.2 | Derivation of the <i>LOOP</i> | 7 |
| 3.2.1 | The Update Matrix | 7 |
| 3.2.2 | The Guard Matrix | 7 |
| 3.2.3 | The Iteration Matrix | 7 |
| 3.3 | Derivation of the <i>SMT</i> -Problem | 7 |
| 3.3.1 | The Domain Criteria | 7 |
| 3.3.2 | The Initiation Criteria | 7 |
| 3.3.3 | The Point Criteria | 7 |
| 3.3.4 | The Ray Criteria | 7 |
| 3.4 | Verification of the Geometric Non-Termination Argument | 7 |
| 4 | Benchmarks | 9 |
| 5 | related work | 11 |
| | Literaturverzeichnis | 11 |

Chapter 1

Introduction

- general topic of termination
- why is it important?
- un-decidability of the Halting-Problem
- *AProVE* and it's way of proving

Chapter 2

Preliminaries

2.1 Considered Programs

2.1.1 Form

2.1.2 Structure

2.2 The Theorem

2.3 Reverse-Polish-Notation-Tree

2.4 *SMT*-Problem

Chapter 3

Geometric Non-Termination

3.1 Derivation of the *STEM*

3.2 Derivation of the *LOOP*

3.2.1 The Update Matrix

3.2.2 The Guard Matrix

3.2.3 The Iteration Matrix

3.3 Derivation of the *SMT*-Problem

3.3.1 The Domain Criteria

3.3.2 The Initiation Criteria

3.3.3 The Point Criteria

3.3.4 The Ray Criteria

3.4 Verification of the Geometric Non-Termination Argument

Chapter 4

Benchmarks

Chapter 5

related work

Bibliography