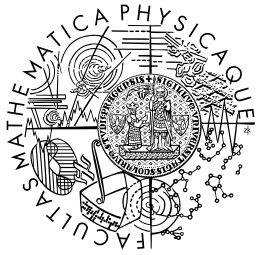

FACULTY
OF MATHEMATICS
AND PHYSICS
Charles University

BACHELOR THESIS

Daniel Crha

Board game with artificial intelligence

Department of Theoretical Computer Science and Mathematical Logic

Supervisor of the bachelor thesis: Mgr. Martin Pilát, Ph.D.
Study programme: Computer Science
Study branch: IOI

Prague 2020

I declare that I carried out this bachelor thesis independently, and only with the cited sources, literature and other professional sources. It has not been used to obtain another or the same degree.

I understand that my work relates to the rights and obligations under the Act No. 121/2000 Sb., the Copyright Act, as amended, in particular the fact that the Charles University has the right to conclude a license agreement on the use of this work as a school work pursuant to Section 60 subsection 1 of the Copyright Act.

In ..... date ....

Author's signature

Most of all I want to thank my supervisor for his help and advice, he was always there for me whenever I needed his opinion. I also thank all of my family and friends for being there for me along the way, my journey has been long and I could not have done it without them.

Title: Board game with artificial intelligence

Author: Daniel Crha

Department: Department of Theoretical Computer Science and Mathematical Logic

Supervisor: Mgr. Martin Pilát, Ph.D., Department of Theoretical Computer Science and Mathematical Logic

Abstract: Multiplayer board games with imperfect information present a difficult challenge for many common game-playing algorithms. Studying their behavior in such games can be difficult, because existing implementations of such games have poor support for artificial intelligence. This thesis aims to implement an imperfect information multiplayer board game in a way that provides a framework for developing and testing artificial intelligences for board games with the aforementioned qualities. Furthermore, this thesis explores the implementation of several algorithms for the game. This aims to showcase the artificial intelligence framework, as well as to analyze the performance of existing algorithms when applied to a board game with elements such as hidden information and multiple players.

Keywords: board game, artificial intelligence

Contents

Introduction **2**

1 Related Work **3**
1.1 Games and Frameworks . . . 3
1.2 Algorithms . . . 3
1.2.1 Minimax . . . 3
1.2.2 Monte-Carlo Methods . . . 3

2 Game Design **4**

3 Framework **5**
3.1 Design . . . 5
3.2 Interface . . . 5

4 Used Algorithms **6**
4.1 Random Decisions . . . 6
4.2 Heuristics . . . 6
4.3 MaxN . . . 6
4.4 Information Set Monte-Carlo Tree Search . . . 6

5 Experiment Description **7**
5.1 Title of the first subchapter of the second chapter . . . 7
5.2 Title of the second subchapter of the second chapter . . . 7

Conclusion **8**

Bibliography **9**

List of Figures **10**

List of Tables **11**

List of Abbreviations **12**

A Attachments **13**
A.1 User Documentation . . . 13
A.1.1 Installation . . . 13
A.1.2 User Interface . . . 13
A.2 Developer Documentation . . . 14
A.2.1 Prerequisites . . . 14
A.2.2 Project Structure . . . 14
A.2.3 Game Engine . . . 14
A.2.4 Artificial Intelligence . . . 14
A.2.5 User Interface . . . 14

Introduction

1. Related Work

An example citation: Anděl [2007]

1.1 Games and Frameworks

1.2 Algorithms

1.2.1 Minimax

1.2.2 Monte-Carlo Methods

2. Game Design

3. Framework

3.1 Design

3.2 Interface

4. Used Algorithms

4.1 Random Decisions

4.2 Heuristics

4.3 MaxN

4.4 Information Set Monte-Carlo Tree Search

5. Experiment Description

5.1 Title of the first subchapter of the second chapter

5.2 Title of the second subchapter of the second chapter

Conclusion

Bibliography

J. Anděl. *Základy matematické statistiky.* Druhé opravené vydání. Matfyzpress, Praha, 2007. ISBN 80-7378-001-1.

List of Figures

List of Tables

List of Abbreviations

A. Attachments

A.1 User Documentation

A.1.1 Installation

A.1.2 User Interface

A.2 Developer Documentation

A.2.1 Prerequisites

A.2.2 Project Structure

A.2.3 Game Engine

A.2.4 Artificial Intelligence

A.2.5 User Interface