UNIVERSITY OF ŽILINA

FACULTY OF ELECTRICAL ENGINEERING

AND INFORMATION TECHNOLOGY

MASTER THESIS

BC., DANIEL ADAMKOVIČ

Realizing walking for a walking robot

using deep reinforcement learning

*The name is a placeholder until I get official english name

Supervisor: Ing. PhD., Michal Gregor

Identifier: 69 69 420

Žilina, 2020

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Namiesto tejto strany treba vložiť zadanie záverečnej práce!

Do elektronickej verzie práce vložte **oskenované podpísané** zadanie záverečnej práce, napr. vo formáte pdf alebo ako obrázok zväčšený na celú veľkosť papiera.

Acknowledgments

Poďakovanie nie je povinné. Ak nemá byť zahrnuté, stačí túto časť zakomentovať.

Abstract

Abstrakt obsahuje informáciu o cieľoch práce, jej stručnom obsahu a v závere abstraktu sa charakterizuje splnenie cieľa, výsledky a význam celej práce. Abstrakt sa píše súvisle ako jeden odsek a jeho rozsah je spravidla 100 až 500 slov.

Keywords: robotics, deep reinforcement learning, artificial intelligence, simulation

Abstrakt

Nejaký abstrakt po slovensky.

Kľúčové slová: robotika, hlboké učenie s odmenou, umelá inteligencia, simulácia

CONTENTS

Dictionary of terms

AI: artificial intelligence (svk. umelá inteligencia)

DRL: deep reinforcement learning (svk. hlboké učenie s odmenou)

RL: reinforcement learning (svk. učenie s odmenou)

1 | Introduction

In the last couple of decades we have witnessed many groundbreaking developments that would have previously been reserved for science fiction. Modern mobile robots can walk, interact with objects and humans, even independently accomplish simple tasks previously only reserved for humans. However while the robots are becoming more complex by the year, so does the complexity of their design and development. This is most obvious with robots that utilize legs for the purposes of locomotion, which forces engineers to develop complex controllers that allow such machines to move about. Design of these controllers is more often than not non-trivial and as such it is often reserved for experienced control engineers. Still, even with a lot of effort success is not guaranteed and even well-designed robots rarely achieve the same grace of movement that animals are capable of.

With this paragraph we have formulated the problem that this thesis addresses. For one way of solving it we can, as engineers often do, draw inspiration from nature. An animal learns to walk, not by performing a deep analysis of its tendons and muscles and then committing months to study of books on control theory. No, an animal learns in a much more straightforward way by simply making attempts and attempting to achieve 'good results'. We write good results in quotation marks as measuring goodness of something can be in practice a difficult and often very subjective task. Regardless, this simple concept of making attempts and obtaining a measure of success is, not only present in nature, it is also at the core of one of the most promising sub-fields of artificial intelligence known as reinforcement learning (RL).

In this text we will focus on:

1. **Introducing deep reinforcement learning (DRL) algorithms**: with RL maturing as a field a slew of different approaches at utilizing it become available. We will explore some of the most promising ones that are relevant for our use case.

2. **Simulation and modeling of a robot, task and reward**: just having an algorithm that works is not enough, so this chapter will be dedicated to creating a simulated environment within which we will train a virtual robot to walk.

3. **Implementing the DRL**:
   When I know more about the implementation details I need to modify this

4. **Training and results analysis**: this chapter will be dedicated to putting everything together and analyzing the obtained results.

5. **Transitioning into the real world**:
   See the comment above

2 | DEEP REINFORCEMENT LEARNING

In this chapter we will put DRL into the context of broader field of artificial intelligence and explain how it differs from other approaches that attempt to imbue agents with some form of intelligence. Afterwards we will proceed to introduce the main algorithms that are relevant for the use in environments with continuous action spaces.

2.1 DRL in the context of AI

Aside from the attempts at creating more-or-less autonomous systems that can be traced to the earliest civilizations the history of modern AI started to be written by early pioneers in the 1950s and 1960s. The term itself is said to be first coined by John McCarthy, who along with many other influential figures met in 1956 at the now famous Dartmouth College conference [1], where the belief that machines could posses something akin to intelligence was solidified. The advances in AI that soon followed were made possible by the improvements in computational power and more focused research efforts. However at this time most works still relied on techniques such as symbol manipulation and trial-and-error search. These early systems could play checkers and simple puzzle games, prove mathematical theorems (Geometry Theorem Prover), carry out simple written commands (SHRDLU) and even control a robot (Shakey) [2]. But while these approaches were promising when applied to smaller well-defined scenarios, one thing they all had in common was their inability to scale well to larger, more realistic situations. In the context of reinforcement learning an important development that happened at this time was early work on neural networks that showed, among other things, that ca perceptron (perceptron = an individual virtual neuron capable of classifying data on its inputs)

Zoznam použitej literatúry

[1] MOOR, J. The Dartmouth CollegeArtificial Intelligence Conference: The Next Fifty Years. *AI Magazine*. 2006.

[2] *Artificial Intelligence: A Modern Approach*. Pearson, 2009.

ČESTNÉ VYHLÁSENIE

Vyhlasujem, že som zadanú prácu vypracoval samostatne, pod odborným vedením vedúceho práce, ktorým bol Ing. PhD., Michal Gregor a používal som len literatúru uvedenú v práci.

Súhlasím so zverejnením práce a jej výsledkov.

Dátum odovzdania práce, Žilina

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podpis

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APPENDICES

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Appendix A | Zeleninový šalát

Tvorba príloh je veľmi jednoduchá – stačí ich pridať ako nové kapitoly v časti dokumentu označenej ako `\appendix`. Prílohy sú automaticky číslované nie numericky, ale písmenami abecedy, čím sú dostatočne odlíšené od klasických kapitol. Ak práca obsahuje prílohy, šablóna automaticky vygeneruje titulný list oddeľujúci prílohovú časť práce od hlavnej časti práce.

A.1 Textová vata

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