

-sometitle-

Classifying N-body simulations with and without relativistic corrections
using machine learning techniques

Johan Mylius Kroken

Computational Science: Astrophysics
60 ECTS study points

Institute of Theoretical Astrophysics
Faculty of Mathematics and Natural Sciences

Johan Mylius Kroken

-sometitle-

Classifying N-body simulations with and without
relativistic corrections using machine learning
techniques

Supervisors:

A David Fonseca Mota

B Julian Adamek

C Francisco Antonio Villaescusa Navarro

Abstract

Here come 3–6 sentences describing your thesis.

Sammendrag

Here comes the abstract in a different language.

Contents

1	Introduction	1
I	Cosmological Structure Formation	3
2	Background Cosmology	5
2.1	Describing the Universe	5
2.2	The Friedmann Equations	5
2.3	Recombination	5
3	Perturbation Theory	7
3.1	Initial Conditions	7
3.2	Transfer Functions	7
3.3	Power Spectra	7
3.4	Non-linear Evolution and the Bispectrum	7
4	Simulations.	9
4.1	N-body simulations	9
4.2	Mass Assignments Schemes	9
II	Machine Learning	11
5	Neural Networks.	13
5.1	Forward pass - Prediction	13
5.1.1	Activation functions.	13
5.1.2	Loss functions.	13
5.2	Backpropagation - Training	13
5.2.1	Gradient descent	13
5.2.2	Optimizers	13
5.2.3	Regularization	13
6	Convolutional Neural Networks	15
6.1	Convolution	15
6.2	New Layers	15
6.2.1	Convolutional layers	15
6.2.2	Pooling layers	15
6.2.3	Dropout layers	15
III	Conclusion	17
7	Results	19

Contents

List of Figures

List of Figures

List of Tables

List of Tables

Preface

Here comes your preface, including acknowledgments and thanks.

Chapter 1

Introduction

Part I

Cosmological Structure Formation

Chapter 2

Background Cosmology

2.1 Describing the Universe

2.2 The Friedmann Equations

2.3 Recombination

Chapter 3

Perturbation Theory

3.1 Initial Conditions

3.2 Transfer Functions

3.3 Power Spectra

3.4 Non-linear Evolution and the Bispectrum

Chapter 4

Simulations

4.1 N-body simulations

4.2 Mass Assignments Schemes

Part II

Machine Learning

Chapter 5

Neural Networks

5.1 Forward pass - Prediction

5.1.1 Activation functions

5.1.2 Loss functions

5.2 Backpropagation - Training

5.2.1 Gradient descent

5.2.2 Optimizers

5.2.3 Regularization

TODO: Add dropout, batch normalization, weight decay, early stopping, data augmentation, etc.

[Betoule__2014]

Chapter 6

Convolutional Neural Networks

6.1 Convolution

6.2 New Layers

6.2.1 Convolutional layers

6.2.2 Pooling layers

6.2.3 Dropout layers

Part III

Conclusion

Chapter 7

Results

