PÁZMÁNY PÉTER CATHOLIC UNIVERSITY

Building, testing and visualizing neural networks from scratch

by

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Declaration of Authorship

I, Botos Csaba, declare that this thesis titled 'Building, testing and visualizing neural networks from scratch', and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this University.
- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
- I have acknowledged all main sources of help.
- Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself.

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"Write a funny quote here."

If the quote is taken from someone, their name goes here

Abstract

Advisor: Istvan Z. Reguly

Recently a special branch of Machine Learning, a model based on living organic systems called Deep Neural Networks overtakes previous paradigm of algorithmic problem solving. It gained larger attention when better results were achieved than task-specific, handcrafted models in feature extraction. The reason behind its success is their scalability: the latest architectures are able to exploit the capacity of cutting-edge GPU hardwares since the abstraction of the data are accomplished by succeeding neural nodes performing elementary operations which can be easily paralellized.

It is of the utmost importance to understand the main concept of such networks to contribute to the breakthroughs of the fourth industrial revolution. To this purpose, building a framework from the base unit blocks of the latest models is the best introduction to Machine Learning. In my research I have disassembled black-box representated networks to the very basic, intuitive level and reorganized it in O.O. manner where each neural layer is treated as an entity derived from a common ancestor, therefore information flow and processes of the system are easily traced. Current implementations are based on the principals of the components used by networks built for ImageNet classification, such as Convolutional, ReLU, Max-Pooling, Fully-Connected, Softmax and k-Winner-Takes-All layers. Furthermore the following training methods and policies were adapted as well: cross validated, minibatch, on-line, L_p regularized and basically Stochastic Gradient Descent training.

For testing the framework, the parameter space of Fully Connected networks was exhaustively explored. After train and evaluating sessions - mainly performed on the MNIST and self-acquisited datasets - the results were gathered to analyze the performance of different architectures. For further investigation the best performing models were compared to each other to find pros and cons of different capacity, layout and training of networks.

Besides architectural experiments, targeted by many recent researches a non-trivial task of visualizing the inner representation of information, understanding transient activation patterns was studied as well. Previously mentioned candidate networks were also visualized individually to retrieve information about characteristics of the processes in their Hidden Layer. My implementation proposes a simplification of the DeConvNet derived from Gradient Ascent, efficient algorithm to reveal patterns recognized by nodes in the hidden layers of Neural Networks, to produce adversarial input samples.

Acknowledgements

The acknowledgements and the people to thank go here, don't forget to include your project advisor...

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Abbreviations

LAH **L**ist **A**bbreviations **H**ere

Physical Constants

Speed of Light $c = 2.997\ 924\ 58 \times 10^8\ \mathrm{ms}^{-\mathrm{S}}$ (exact)

Symbols

a	distance	m
P	power	W (Js^{-1})
ω	angular frequency	$rads^{-1}$

For/Dedicated to/To my...

Chapter 1

Introduction

Tendencies shows that by introducing machine learning to extract informations from otherwise uncontrollable big data results in a leap-forward in main fields of marketing, media and researches. The key behind such efficiency is pattern recognition in high dimension spaces. When it comes to developement of architectures for finding optimal solutions usually the system is compared to human performance in cases which we think are easily solved. For better understanding the mechanism, furthermore the flaws of instances of artificial intelligence, the best is to disassemble the core idea to building blocks in a TOP-DOWN manner, analyze each component separatively, and (re-)implement it step-by-step. After doing so, revealing the processes behind the architecture will be more intuitive than approaching the paradigm as a black box.

1.1 A Section

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Appendix A

An Appendix

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