

Czech Technical University in Prag  
Faculty of Mechanical engineering

Department of instrumentation and control engineering  
Automation and industry informatics



Master Thesis

**Title**

Subtitle

January 29, 2021

**Roman Dušek**

# Contents

<b>1</b>	<b>Introduction</b>	<b>4</b>
<b>2</b>	<b>Background</b>	<b>4</b>
2.1	Supervised learning . . . . .	4
2.2	Neural networks . . . . .	4
2.2.1	Perceptron . . . . .	4
2.2.2	Learning and optimalization . . . . .	4
2.3	Recurrent neural networks . . . . .	4
2.3.1	Vanilla version . . . . .	4
2.3.2	Long-short-term-memories . . . . .	4
2.3.3	Gated recurrent units . . . . .	4
2.3.4	Other types of RNN . . . . .	4
2.3.5	Problems using RNN . . . . .	4
2.4	High order neural networks . . . . .	4
2.4.1	High order neural unit . . . . .	4
2.4.2	Recurrent HONN . . . . .	4
2.4.3	Problems using HONN . . . . .	4
<b>3</b>	<b>Experimental Setup</b>	<b>4</b>
<b>4</b>	<b>Discussion</b>	<b>4</b>
<b>5</b>	<b>Conclusion</b>	<b>4</b>
	<b>References</b>	<b>5</b>
	<b>Appendix</b>	<b>6</b>

## Nomenclature

GRU	Gated Recurrent Unit
HONN	High Order Neural Network
HONU	High Order Neural Unit
LSTM	Long-Short-Term Memory
NN	Neural network
RHONN	Recurrent High Order Neural Network
RNN	Recurrent Neural network

<b>1</b>	<b>Introduction</b>
<b>2</b>	<b>Background</b>
2.1	Supervised learning
2.2	Neural networks
2.2.1	Perceptron
2.2.2	Learning and optimalization
2.3	Recurrent neural networks
2.3.1	Vanilla version
2.3.2	Long-short-term-memories
2.3.3	Gated recurrent units
2.3.4	Other types of RNN
2.3.5	Problems using RNN
2.4	High order neural networks
2.4.1	High order neural unit
2.4.2	Recurrent HONN
2.4.3	Problems using HONN
<b>3</b>	<b>Experimental Setup</b>
<b>4</b>	<b>Discussion</b>
<b>5</b>	<b>Conclusion</b>

## References

- [1] Filippo Maria Bianchi et al. *Recurrent Neural Networks for Short-Term Load Forecasting: An Overview and Comparative Analysis*. en. 1st ed. 2017. SpringerBriefs in Computer Science. Cham: Springer International Publishing : Imprint: Springer, 2017. ISBN: 978-3-319-70338-1. DOI: [10.1007/978-3-319-70338-1](https://doi.org/10.1007/978-3-319-70338-1).
- [2] Ivo Bukovský. “Nonconventional Neural Architectures and Their Advantages for Technical Applications”. In: ().
- [3] L.R. Desker and L.C. Jain. *Recurrent Neural Networks Design and Applications*.
- [4] Ian Goodfellow, Yoshua Bengio, and Aaron Courville. *Deep Learning*.
- [5] M. Madan Gupta and Ivo Bukovsky. “Fundamentals of Higher Order Neural Networks for Modeling and Simulation”. In: ().
- [6] LazyProgrammer. *Recurrent Neural Networks in Python*.
- [7] Danilo Mandic and Jonathon A. Chambers. “Recurrent Neural Networks for Prediction Learning Algorithms, Architectures, and Stability by Danilo Mandic, Jonathon Chambers”. In: ().
- [8] Danilo P. Mandic and Jonathon A. Chambers. *Recurrent Neural Networks for Prediction*. en. Ed. by Simon Haykin. Wiley Series in Adaptive and Learning Systems for Signal Processing, Communications, and Control. Chichester, UK: John Wiley & Sons, Ltd, Aug. 2001. ISBN: 978-0-471-49517-8 978-0-470-84535-6. DOI: [10.1002/047084535X](https://doi.org/10.1002/047084535X).
- [9] Christopher Olah. *Understanding LSTM Networks*. en. Aug. 2015.
- [10] Jorge D. Rios et al. *Neural Networks Modeling and Control: Applications for Unknown Nonlinear Delayed Systems in Discrete Time*. en. First. Waltham: Elsevier, 2019. ISBN: 978-0-12-817078-6.
- [11] Ming Zhang. *Artificial Higher Order Neural Networks for Economics and Business*. en.

# Appendix