Contents

1	Intr	Introduction 1													
	1.1	Multi-relational learning	1												
		1.1.1 Factorization models for Multi-relational data	4												
		1.1.2 Applications of Multi Relational Learning	5												
	1.2	Contribution	6												
	1.3	Submitted and Published Work	7												
	1.4	Chapter Overview	9												
2	The	Multi-Relational Factorization Problem 1	1												
	2.1	Problem Formulation	12												
	2.2	State of the Art	14												
		2.2.1 Parametrization of Multi-relational factorization models . 1	15												
		2.2.2 Optimization objectives for multi-relational learning	18												
		2.2.3 Summary of the presented models	21												
	2.3	Evaluating Multi-Relational Learning Models	21												
	2.4		23												
3	Los	functions for multi-relational learning tasks	26												
	3.1	3.1 Application scenario: Mining RDF Knowledge Bases													
		3.1.1 RDF inference and Related Work	28												
	3.2	Predicting RDF Triples	30												
	3.3	Predicting RDF triples by Tensor Factorization	31												
		3.3.1 Factorization Models	31												
		3.3.1.1 Three-way Interaction Model	31												
			32												
		3.3.2 The open world assumption and the loss function	33												
		3.3.3 Dealing with the open world assumption through the BPR													
		_	35												
			36												

	3.4	Evalua	ation												
		3.4.1	Datasets												
		3.4.2	Methods												
		3.4.3	Evaluation Methodology 41												
		3.4.4	Results												
		3.4.5	Comparing BPR against RMSE												
		3.4.6	Evaluation of Type information through Post Filter 45												
	3.5	Conclu	usions												
4	Tar	get-Sp	ecific Parametrization of Multi-Relational Models 51												
4.1 Learning with multiple target relations															
	4.2		Target Factorization												
		4.2.1	Optimizing models for Multiple Target Relations 54												
		4.2.2	Coupled Auxiliary and Target Specific Factorization 57												
		4.2.3	Setting up CATSMF												
	4.3		ation												
	1.0	4.3.1	Comparison against the state-of-the-art 62												
		4.3.2	Evaluation Protocol and Metrics 64												
		4.3.3	Experiment I: Benchmark Datasets												
		4.3.4	Experiment II: Web Datasets 6												
	4.4		usion												
5	Fac		ion models for Semi-Supervised Classification 76 Supervised Classification 7												
	5.1	Com Supervisor Comments of the													
	5.2 Related Work														
		5.2.1	Semi-Supervised learning												
		5.2.2	Multi-Relational Factorization for Semi-Supervised Classi-												
			fication												
	5.3		supervised classification problem formulation 8 rization models for Semi-supervised Classification 8												
	5.4	5.4 Factorization models for Semi-supervised Classification													
		5.4.1	Neighborhood Based Feature Extraction 8												
		5.4.2	Semi-Supervised Learning of PNT-CMF 8												
		5.4.3	Learning Inductive Factorization models for Classification 9												
	5.5	Evalu	ation												
		5.5.1	Datasets												
		5.5.2	Setup												
		5.5.3	Baselines												
		5.5.4	Model Selection												
		5.5.5	Results and discussion												

CONTENTS

	5.6	Conclusion				•	•								•												98
6	Conclusion 6.1 Summary																									100	
	6.1	Summary																									100
		Discussion																									
	6.3	Future Dire	ection	ı				•													•					•	102
In	dex																										106
References														114													