

Carstens · Ontology Based Query Expansion

Schriften zur Informationswissenschaft Band 60

Herausgegeben vom Hochschulverband
für Informationswissenschaft (HI) e.V. Konstanz

Mitglieder des wissenschaftlichen Beirates für die Schriftenreihe:

Nicolas Belkin	Rutgers University
Hans Peter Frei	ETH Zürich
Rainer Hammwöhner	Universität Regensburg
Ilse M. Harms	Universität des Saarlandes
Norbert Henrichs	Universität Düsseldorf
Josef Herget	Donau-Universität Krems
Gerhard Knorz	Hochschule Darmstadt
Jürgen Krause	Universität Koblenz-Landau IZ Sozialwissenschaften
Rainer Kuhlen	Universität Konstanz
Klaus-Dieter Lehmann	Präsident der Stiftung Preußischer Kulturbesitz
Hans-Jürgen Manecke	TU Ilmenau
Achim Oßwald	Fachhochschule Köln
Wolf Rauch	Universität Graz
Harald Reiterer	Universität Konstanz
Marc Rittberger	Hochschule Darmstadt/DIPF
Christian Schlögl	Universität Graz
Wolfgang Semar	HTW Chur
Dagobert Soergel	University of Maryland
Wolfgang G. Stock	Universität Düsseldorf
Christa Wolff	Universität Regensburg
Christa Womser-Hacker	Universität Hildesheim
Harald Zimmermann	Universität des Saarlandes

Carola Carstens

Ontology Based Query Expansion

**Retrieval Support for the
Domain of Educational Research**

vwh

Verlag Werner Hülsbusch
Fachverlag für Medientechnik und -wirtschaft

C. Carstens: Ontology Based Query Expansion

Bibliografische Information der Deutschen Nationalbibliothek

Die Deutsche Nationalbibliothek verzeichnet diese Publikation in der Deutschen Nationalbibliografie; detaillierte bibliografische Daten sind im Internet unter <http://d-nb.de> abrufbar.

© Verlag Werner Hülsbusch, Boizenburg, 2012

vwh Verlag Werner Hülsbusch
Fachverlag für Medientechnik und -wirtschaft

www.vwh-verlag.de

Einfache Nutzungsrechte liegen beim Verlag Werner Hülsbusch, Boizenburg.
Eine weitere Verwertung im Sinne des Urheberrechtsgesetzes ist nur mit Zustimmung des Autors möglich.

Markenerklärung: Die in diesem Werk wiedergegebenen Gebrauchsnamen, Handelsnamen, Warenzeichen usw. können auch ohne besondere Kennzeichnung geschützte Marken sein und als solche den gesetzlichen Bestimmungen unterliegen.

Druck und Bindung: Kunsthaus Schwanheide

Printed in Germany

Zugleich: Diss., Univ. Hildesheim, 2011

– Als Manuskript gedruckt –

ISSN: 0938-8710

ISBN: 978-3-86488-011-7

Ontology Based Query Expansion – Retrieval Support for the Domain of Educational Research

Dissertation accepted by
Department III (Linguistics and Information Science)
of the University of Hildesheim

for obtaining the degree of
Dr. phil. in Information Science

by
Carola Carstens
born in Walsrode (03.04.1981)

Supervisors

Prof. Dr. Christa Womser-Hacker (University of Hildesheim)

Prof. Dr. Thomas Mandl (University of Hildesheim)

Prof. Dr. Marc Rittberger (German Institute for International
Educational Research)

Date of disputation

31.08.2011

Disclaimer

The views expressed in this thesis are the sole responsibility of the author and in no way represent the view of the European Commission and its services.

Acknowledgements

This thesis was realised during my work as a research assistant at the Information Center for Education of the German Institute for International Educational Research (DIPF) in Frankfurt am Main, Germany. I am grateful to my colleagues at the Information Center for creating a very supportive atmosphere for my research.

Table of Contents

1	Introduction	11
2	Ontologies	15
2.1	Basic Concepts	15
2.1.1	Definition of Ontologies	15
2.1.2	Basic Elements of Ontologies	16
2.1.3	Ontologies and Other Knowledge Structures	17
2.1.4	Types of Ontologies	21
2.2	Ontologies in the Semantic Web	23
2.2.1	Semantic Web Technologies	23
2.2.2	Semantic Web Tools	28
2.2.3	Research Context-Related Data on the Semantic Web	29
3	Retrieval	33
3.1	Information Retrieval	33
3.1.1	Definition of Information Retrieval	33
3.1.2	Information Retrieval versus Data Retrieval	36
3.1.4	Traditional versus Interactive Information Retrieval Models	42
3.2	Evaluation of Information Retrieval Systems	45
3.2.1	Design of Retrieval Experiments	45
3.2.2	Automatic versus Interactive Retrieval Experiments	46
3.2.3	The TREC Initiative	50
3.2.4	Evaluation Measures	59
4	Query Expansion	69
4.1	Definition of Query Expansion	69
4.2	Query Expansion Methods	72
4.3	Effectiveness of Query Expansion Methods	74
4.3.1	Query Expansion Based on Search Results	75
4.3.2	Query Expansion Based on Collection Dependent Knowledge Structures	76
4.3.3	Query Expansion Based on Collection Independent Knowledge Structures	77
4.4	Knowledge Structures for Collection Independent Query Expansion	79
4.4.1	Query Expansion Based on Thesauri	79

4.4.2	Query Expansion Based on WordNet	83
4.4.3	Query Expansion Based on Ontologies	85
4.5	Evaluation Methods for Collection Independent Query Expansion	87
5	Search Behavior	97
5.1	Query Characteristics	98
5.2	Search Strategies	99
5.3	Search Tactics	101
5.4	Strategic Search Support	102
5.5	Studies on Search Behavior	104
5.6	Search Behavior in the German Education Index	107
5.6.1	Document Corpus and Indexing Vocabulary	108
5.6.2	Search Functionalities	109
5.6.3	Users	110
5.6.4	Findings	111
6	Research Interest and Experimental Framework	117
6.1	Summary of the State of the Art	117
6.2	Overview of Experimental Design	122
6.3	Research Questions	123
6.4	Experimental Variables	131
6.5	Ontological Knowledge Base	132
6.5.1	The RESCON Ontology Schema	133
6.5.2	Integration of Data from Original Data Sources	136
6.6	Prototypical Ontology Based Query Expansion System	141
6.7	Document Corpus	144
7	Automatic Query Expansion Experiments	145
7.1	Experiments for Concept Queries	146
7.1.1	Test Queries	147
7.1.2	Relevance Judgments	151
7.1.3	Evaluation Measures	154
7.2	Query Expansion Effects for Concept Queries	157
7.2.1	Semantic Relations' Expansion Effects on Baseline Queries	158
7.2.2	Semantic Relations' Average Query Expansion Effects	164
7.2.3	Significance of Differences between Semantic Relations' Query Expansion Effects	166

7.2.4	Semantic Relations' Evaluation Measure Value Distributions	172
7.3	Term Frequency-Dependent Analysis of the Relations' Query Expansion Effects for Concept Queries	182
7.3.1	Influence of Expansion Terms' Document Frequencies	183
7.3.2	Relation-Specific Populations of Frequency Categories	189
7.3.3	Frequency Category-Specific Expansion Effects of Semantic Relations	192
7.3.4	Semantic Relations' Suitability for the Automatic and Interactive Query Expansion Modes	207
7.4	Experiments for Organization and Project Queries	212
7.4.1	Test Queries	212
7.4.2	Relevance Judgments	213
7.4.3	Evaluation Measures	214
7.5	Query Expansion Effects for Organization and Project Queries	215
7.5.1	Expansion with Preferred Labels	216
7.5.2	Expansion with Alternative Labels	222
7.5.3	Disambiguated Expansion with Alternative Labels and Context Information	227
7.6	Conclusion for Automatic Query Expansion Experiments	233
7.6.1	Semantic Relations' Effects for the Expansion of Concept Queries	234
7.6.2	Semantic Relations' Effects for the Expansion of Project and Organization Queries	237
7.6.3	Methodological Discussion	238
8	Interactive Query Expansion Experiments	243
8.1	Experimental Design	245
8.2	Data Collection Methods	247
8.3	Test Persons	252
8.4	Topics	257
8.5	Relevance Judgments	259
8.6	Evaluation Measures	261
8.7	Significance Tests for System Comparisons	262
8.8	Retrieval System Versions	264
8.8.1	Baseline System	264
8.8.2	Automatic System	267
8.8.3	Interactive System	270
8.9	Experimental Results	279
8.9.1	Subjective Ratings of the Systems' Shared Functionalities	280
8.9.2	Subjective Ratings of the Query Expansion Functionalities	288

8.9.3	Recall	294
8.9.4	Number of Collected Documents	298
8.9.5	DistinctDocuments Measure	301
8.9.6	Precision	306
8.9.7	Pre-Click Confidence	309
8.9.8	Number of Query Reformulations	311
8.9.9	Fraction of Interactive Reformulation Steps	314
8.9.10	Effects of Interactive Reformulation Steps	316
8.9.11	Types of Query Reformulations	320
8.9.12	Query Complexity	327
8.10	Conclusion for Interactive Query Expansion Experiments	330
8.10.1	Potential of Ontology Based Query Expansion	330
8.10.2	Effectiveness of Ontology Based Query Expansion	331
8.10.3	Query Expansion Behavior	337
8.10.4	Methodological Discussion	341
9	Interpretation of Experimental Results	347
9.1	Novelty	347
9.2	Related Work	351
9.3	Further Research	357
9.4	Applicability of Experimental Results to the GEI Environment	364
10	Conclusion	369
	References	371
	List of Abbreviations	385
	List of Tables	387
	List of Figures	391
	Appendices *)	WWW

*) Der Anhang ist online abrufbar unter <http://www.vwh-verlag.de/vwh/?p=719>.