

Complex Data Analytics with Formal Concept Analysis

Rokia Missaoui • Léonard Kwuida
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Editors

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 Springer

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In memory of Vincent Duquenne
27.06.1950–26.02.2020.

Foreword

It was in 1970s that Galois connections and respective lattices of closed sets (studied before in Mathematics by Garrett Birkhoff and Oystein Ore) were found useful for modeling information structures and processes [3,26]. After several decades of research in formal concept analysis (FCA) no one can say now that FCA proposes hardly scalable techniques for the analysis of binary data. Highly efficient FCA algorithms with various options for approximation strategies are now widely used for the analysis of complex voluminous heterogeneous data.

In spite of intrinsic complexity of computational problems related to unrestricted generation of both formal concepts and implication bases [15,16], several efficient FCA algorithms were found already around year 2000 [10,19] and new efficient implementations show excellent scalability [1]. Numerous approaches to partial generation of concepts and implications were proposed, based on interestingness constraints [17] and probabilistic considerations [2,5].

Models for treating complex data with FCA-based approaches are manifold. Several approaches were proposed and developed for relational data, first considered through the prism of conceptual scaling, which reduces complex data to binary (or unary, in terms of Rudolf Wille). Most popular approaches to treating complex data in FCA “directly”, i.e., without binarizing (scaling, in FCA terms) them, are logical concept analysis [7], pattern structures [9], fuzzy concept analysis [4], relational concept analysis [11], triadic concept analysis [13,20,22,23], polyadic CA [25], and probabilistic FCA [14]. Recent interest in natural language processing, knowledge graphs, and social network analysis inspired development of new FCA-based approaches [6,8,12,21].

The recent wave of interest in deep neural networks is tempered by the problems of explainability and robustness of proposed solutions. For some applied domains, like medicine, law, and finance, these issues are crucial: experts would not accept efficient accurate solutions that do not provide acceptable explanations. FCA can propose a broad scope of tools for finding interpretable solutions, since explainability is in the core of FCA. Several attempts were made already to combine neural network efficiency with explainability provided by FCA-based approaches [18,24].

This volume presents an important step in all the above-mentioned directions: meeting the challenge of big and complex data, combining FCA-based approaches with methods based on neural networks to guarantee explainability of results.

Moscow, Russia
August 2020

Sergei O. Kuznetsov

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Preface

With the advent of complex and big data and the increasing number of studies towards their management and analysis, it becomes important to get a better insight into existing studies, trends, and challenges and rely on promising theories such as formal concept analysis (FCA) together with recently developed technologies to design new, accurate, and scalable solutions for big data analytics facilities.

FCA is an important formalism that is associated with a variety of research areas such as lattice theory, knowledge representation, data mining, machine learning, and semantic Web, to name a few. It is successfully exploited in an increasing number of application domains such as software engineering, information retrieval, social network analysis, and bioinformatics. The mathematical power of FCA comes from its concept lattice formalization in which each element captures a formal concept while the whole structure represents a hierarchy that offers conceptual clustering, browsing, and association rule mining.

Although there are significant theoretical and practical contributions within the FCA community, including the design and implementation of efficient algorithms and tools for concept lattice computation and exploitation, this book examines a set of important and relevant research directions in complex data management and updates the contribution of the FCA community for analyzing complex and large data. For example, formal concept analysis and some of its extensions are exploited, revisited, and coupled with recent processing paradigms to maximize the benefits in analyzing large data. This book is a follow-up project of the workshop BigFCA'2019—Formal Concept Analysis in the Big Data Era—which was jointly organized with the ICFCA'2019 Conference in Frankfurt (see <https://icfca2019.frankfurt-university.de/bigfca.html>).

This volume of eleven chapters is meant to cover the state of the art of the research on the intersection of FCA and complex data analysis in a more systematic and detailed manner than it was done in the workshop proceedings mentioned above.

Gatineau, QC, Canada
Bern, Switzerland
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Contents

1	Formal Concept Analysis and Extensions for Complex Data Analytics	1
	Léonard Kwuida and Rokia Missaoui	
1.1	Introduction	1
1.2	Background	2
1.2.1	Formal Concepts and Line Diagrams	2
1.2.2	Non Binary Data	4
1.2.3	Implication Computation	6
1.3	Extensions to FCA	7
1.3.1	Logical FCA	7
1.3.2	Fuzzy FCA	7
1.3.3	Relational Concept Analysis	7
1.3.4	Triadic Concept Analysis	8
1.3.5	Approximation	9
1.4	Complex Data Analytics	10
1.5	Contributions	11
	References	13
2	Conceptual Navigation in Large Knowledge Graphs	17
	Sébastien Ferré	
2.1	Introduction	17
2.2	Graph-FCA: Extending FCA to Knowledge Graphs	19
2.2.1	Graph Context	19
2.2.2	Graph Patterns	21
2.2.3	Graph Concepts	21
2.2.4	Graph Concept Lattice	23
2.3	Conceptual Navigation in Graph-FCA Lattices	23
2.3.1	Abstract Conceptual Navigation (ACN)	25
2.3.2	Graph-ACN: Instantiating ACN to Knowledge Graphs	27
2.4	Scaling to Large RDF Graphs with SPARQL Endpoints	30
2.4.1	From Graph-FCA to RDF and SPARQL	31

2.4.2	Computing the Result, Index, and Links	32
2.4.3	Living with Partial Results	35
2.5	Rising in Expressivity	35
2.5.1	An Algebraic Form of Queries	36
2.5.2	Extensions of the Query Algebra	37
2.6	The Sparklis Tool and Application Cases	38
2.6.1	Sparklis	38
2.6.2	Application Cases	40
2.7	Conclusion and Perspectives	42
	References	43
3	FCA2VEC: Embedding Techniques for Formal Concept Analysis . . .	47
	Dominik Dürschnabel, Tom Hanika, and Maximilian Stubbemann	
3.1	Introduction	47
3.2	Related Work	48
3.3	Foundations	49
3.3.1	Formal Concept Analysis	49
3.3.2	Word2Vec	50
3.4	Modeling	52
3.4.1	Retrieving FCA Features Through Closure2Vec	52
3.4.2	Object2Vec and Attribute2Vec	57
3.5	Experiments	60
3.5.1	Object2Vec and Attribute2Vec	61
3.5.2	FCA Features Through Closure2Vec	66
3.6	Conclusion	70
	References	71
4	Analysis of Complex and Heterogeneous Data Using FCA and Monadic Predicates	75
	Karell Bertet, Christophe Demko, Salah Boukhetta, Jérémy Richard, and Cyril Faucher	
4.1	Introduction	75
4.2	The NEXTPRIORITYCONCEPT Algorithm	76
4.2.1	Formal Concept Analysis	76
4.2.2	NEXTPRIORITYCONCEPT	77
4.3	Use Cases	88
4.3.1	Binary and Categorical Characteristics with the Lenses Dataset	88
4.3.2	Numerical Characteristics with the Iris Dataset	91
4.3.3	Sequential Characteristics with the Daily-actions Dataset	96
4.3.4	Sequential Characteristics with the Wine City Dataset	98
4.4	Conclusion	101
	References	102

5 Dealing with Large Volumes of Complex Relational Data Using RCA 105
 Agnès Braud, Xavier Dolques, Alain Gutierrez, Marianne Huchard, Priscilla Keip, Florence Le Ber, Pierre Martin, Cristina Nica, and Pierre Silvie

5.1 Introduction 105

5.2 Background 107

5.3 Related Work 111

5.4 RCA for Environmental Data 114

5.4.1 Two Complex Datasets from the Environmental Domain 114

5.4.2 Experimenting RCA Algorithms 115

5.4.3 Discussion 121

5.5 Analysing Sequences from Water Quality Monitoring Using RCA 122

5.5.1 RCA-Seq 123

5.5.2 Experiments 126

5.5.3 Navigating the Resulting Hierarchy of Graphs 127

5.6 Conclusion 129

References 130

6 Computing Dependencies Using FCA 135
 Jaume Baixeries, Victor Codocedo, Mehdi Kaytoue, and Amedeo Napoli

6.1 Introduction 135

6.2 Notation 137

6.2.1 Equivalence Relation 137

6.2.2 Tolerance Relations 138

6.3 FCA and Database Dependencies 140

6.3.1 Functional Dependencies 140

6.3.2 Similarity Dependencies 141

6.3.3 Formal Concept Analysis 141

6.3.4 Functional Dependencies as Implications 142

6.3.5 Pattern Structures 143

6.4 Results 144

6.4.1 Characterization of Functional Dependencies with Pattern Structures 144

6.4.2 Similarity Dependencies 146

6.5 Discussion 146

6.6 Conclusions 148

References 148

7 Leveraging Closed Patterns and Formal Concept Analysis for Enhanced Microblogs Retrieval 151
 Meryem Bendella and Mohamed Quafafou

7.1 Introduction 151

7.2 Related Work 152

- 7.3 FCA-Based Query Expansion 154
 - 7.3.1 Patterns Discovery 154
- 7.4 Patterns and Word Embeddings Based Query Expansion 155
 - 7.4.1 Word Embeddings: Word2Vec Model 156
 - 7.4.2 Expansion Terms Selection 157
- 7.5 Experiments 158
 - 7.5.1 Dataset Description 158
 - 7.5.2 Retrieval Model 159
 - 7.5.3 Experimental Protocol 159
 - 7.5.4 Experimental Results 160
- 7.6 Conclusion 163
- References 164

- 8 Scalable Visual Analytics in FCA 167**
 - Tim Pattison, Manuel Enciso, Ángel Mora, Pablo Cordero, Derek Weber,
and Michael Broughton
 - 8.1 Introduction 167
 - 8.1.1 Scalable Visual Analytics in FCA 168
 - 8.1.2 Organisation 169
 - 8.2 Graph-Theoretic Introduction to FCA 169
 - 8.2.1 Formal Context 170
 - 8.2.2 Formal Concepts 170
 - 8.2.3 Concept Lattice Digraph 171
 - 8.2.4 Line Diagram 172
 - 8.2.5 Simplifying Implications 172
 - 8.2.6 Visualising Implications 173
 - 8.2.7 Coordinating Views of Implications and Concepts 174
 - 8.3 Introduction to Visual Analytics 175
 - 8.3.1 Algorithmic Analysis 176
 - 8.3.2 Graph Drawing 177
 - 8.3.3 Information Visualisation 177
 - 8.3.4 Multiple Coordinated Views 178
 - 8.3.5 Tight Coupling 178
 - 8.4 Layout, Visualisation and Interaction 179
 - 8.4.1 Reducing Digraph Size 179
 - 8.4.2 Layout of Line Diagram 179
 - 8.4.3 Interactive Visualisation 180
 - 8.4.4 Discovering or Imposing Tree Structure 181
 - 8.4.5 Demand for Enhanced Tool Support 181
 - 8.4.6 Implications 182
 - 8.5 Three FCA Prototypes 182
 - 8.5.1 Hierarchical Parallel Decomposition 182
 - 8.5.2 User-Guided FCA 183
 - 8.5.3 Structural Navigation 186

- 8.6 Discovering Insightful Implications 188
 - 8.6.1 Visualisation of Implications 188
 - 8.6.2 Our Data Visualisation Approach 192
- 8.7 Conclusions and Future Work 196
- References 196
- 9 Formal Methods in FCA and Big Data 201**

Domingo López-Rodríguez, Emilio Muñoz-Velasco, and Manuel Ojeda-Aciego

 - 9.1 Introduction 201
 - 9.2 Context and Concept Lattice Reduction Methods 204
 - 9.3 Improved Management of Implications 209
 - 9.4 Minimal Generators to Represent Knowledge 214
 - 9.5 Probably Approximately Correct Implication Bases 216
 - 9.6 Summary and Possible Future Trends 219
 - References 221
- 10 Towards Distributivity in FCA for Phylogenetic Data 225**

Alain Gély, Miguel Couceiro, and Amedeo Napoli

 - 10.1 Motivation 225
 - 10.2 Models: Lattices, Semilattices, Median Algebras and Median Graphs 227
 - 10.2.1 Lattices and FCA 227
 - 10.2.2 Distributive Lattices 230
 - 10.2.3 Median Graphs 232
 - 10.3 Algorithm to Produce a Distributive \vee -Semilattice 233
 - 10.4 A Counter-Example for the Existence of a Minimum Distributive \vee -Semilattice 235
 - 10.5 Discussion and Perspectives 236
 - References 236
- 11 Triclustering in Big Data Setting 239**

Dmitry Egrunov, Dmitry I. Ignatov, and Dmitry Tochilkin

 - 11.1 Introduction 239
 - 11.2 Prime Object-Attribute-Condition Triclustering 241
 - 11.3 Triclustering Extensions 244
 - 11.3.1 Multimodal Clustering 244
 - 11.3.2 Many-Valued Triclustering 245
 - 11.4 Implementations 245
 - 11.4.1 Map-Reduce-Based Multimodal Clustering 245
 - 11.4.2 Implementation Aspects and Used Technologies 248
 - 11.4.3 Parallel Many-Valued Triclustering 249
 - 11.5 Experiments 249
 - 11.5.1 Datasets 250
 - 11.5.2 Results 251

11.6 Experiments with Parallelisation	253
11.7 Conclusion	254
References	256
Index	259

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Acronyms

ACN	Abstract Conceptual Navigation
FCA	Formal Concept Analysis
FD	Functional Dependency
IR	Information Retrieval
KG	Knowledge Graph
NLP	Natural Language Processing
OA	Object-Attribute
OAC	Object-Attribute-Condition
PAC	Probably Approximately Correct
PGP	Projected Graph Pattern
RCA	Relational Concept Analysis
TCA	Triadic Concept Analysis