

FCA Tools Bundle

Diana Cristea, Christian Săcărea, and Diana-Florina Şotropa

Babeş-Bolyai University Cluj-Napoca

dianat@cs.ubbcluj.ro, csacarea@cs.ubbcluj.ro, diana.halita@ubbcluj.ro

Abstract. Formal Concept Analysis is well known for the intuitive and graphical representations of lattices. While there are a lot of algorithms mining for formal concepts in the dyadic case, there are not many tools offering this feature for multidimensional datasets. The purpose of this paper is to present **FCA Tools Bundle** and its various features, ranging from importing the data in several formats to offering full support to explore your data using different navigation and exploration methods.

1 Introduction

As an applied discipline, dealing with collections of knowledge, so-called concepts, and aiming to detect, extract, process and represent patterns in various data sets, FCA needs powerful software tools for handling not only the "classical" dyadic case - formal contexts and lattice representation, but also many-valued contexts, conceptual scale building, triadic FCA, pattern structures, etc. While the theory developed quickly, many software tools have been developed, but they are rather specialized on one topic than to provide a collection of tools. In this paper we present **FCA Tools Bundle**, a collection of tools covering not only the dyadic case, but also handling many-valued contexts, supporting scale building and conceptual browsing.

2 Related Work

While FCA focuses on data visualization and exploration, there are multiple algorithms and software tools supporting it. An overview of this developing effort is maintained by Uta Priss on her page ¹. Among them we briefly recall **ToscanaJ Suite** [2], which is a Java implementation of the former tool **Toscana** and was for many years the only tool to handle many-valued contexts. It includes tools to create a formal context, perform conceptual scaling on a context, compute the formal concepts and the corresponding concept lattice. Since all these features are vital to FCA, they were also included in **FCA Tools Bundle**. Other important algorithms and tools include: **Trias** [3], which is one of the few algorithms

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¹ <http://www.upriss.org.uk/fca/fcasoftware.html>

that deals with triadic data or `Lattice miner`² [8], a tool that implements generation and visualization of concept lattices. While most FCA tools focus on basic features such as lattice visualization, and concept generation, some tools try to integrate multiple features. For instance, `LatViz` [1] integrates functionalities such as visualization of Pattern Structures and implications, AOC posets, concept annotations.

3 FCA Tools Bundle - Motivation and Features

While many of the FCA features are available in at least one software, the problem lies in the fact that there does not exist a tool integrating all the features. Also many of the tools, while being useful to FCA experts, are hard to use for non experts. Therefore, making FCA more popular outside of its natural community is another goal which motivates the development of `FCA Tools Bundle`³.

A first version of the tool which was focused on navigation through the concepts was presented earlier in more details [4]. However, since then new features were added to the tool, such as: scale building and computing weak analogical proportions. The `FCA Tools Bundle` currently implements features for dyadic and triadic FCA, bridging the gap between the dyadic and the many-valued case. Besides basic features, the tool includes some new approaches regarding data exploration, such as constraint based navigation in n -adic datasets and the visualization of weak analogical proportions in concept sets. Because the lack of space we will enumerate the tools features, but we will only get into details for some of the features that stand out. The list of features integrated in `FCA Tools Bundle` includes the following:

1. Create dyadic or triadic contexts;
2. Import polyadic contexts and generate the correspondent concept set;
3. Build and view concept lattices;
4. Find a concept in a polyadic context without generating all its concepts;
5. Local navigation in triadic concept sets;
6. Import many-valued contexts and build conceptual scales;
7. Find Weak Analogical Proportions in concept sets;

To start exploring your own data the tool offers several methods of creating the context: manually or by importing different formats. Conceptual scaling was integrated in `FCA Tools Bundle` in a user friendly way as seen in Figure 1. Currently the tool supports the nominal, ordinal, interordinal, grid or custom scales. Moreover, the concept lattices generation was improved using a detection collision algorithm, in order to avoid manually arranging the concept lattice for concept visibility.

As mentioned previously, `FCA Tools Bundle` concentrates not only on dyadic, but also on n -adic contexts. Therefore, the tool has integrated `Trias` [3] in order

² <https://sourceforge.net/projects/lattice-miner>

³ <https://fca-tools-bundle.com/>

The screenshot shows the 'Step 3: Provide Type Specific Scale Data' interface. It is split into two identical columns for the 'Column: RAM' selection. Each column contains radio buttons for 'Order' (Increasing, Decreasing) and 'Bounds' (Include, Exclude). Below these are 'Add Value' buttons and input fields. The left column's input fields contain '1000' and '2000', while the right column's contain '10' and '20'. Each input field has a red 'Remove' button to its right. At the bottom of the interface are three buttons: 'Cancel' (red), 'Back' (grey), and 'Submit' (blue).

Fig. 1: Generating a grid scale in FCA Tools Bundle

to generate a list of concepts in a triadic context. Based on the generated tri-concepts the tool offers a navigation through a triadic context based on dyadic projections. This navigation paradigm was described in more details and analyzed formally in previous papers [10, 4].

On the other hand, when dealing with n -adic datasets there are not many algorithms computing formal concepts. Another important aspect that we took into consideration is exploring a large dataset from the perspective of a user that is looking for a cluster of elements having some particular properties. This led us to the idea of a constraint based concept exploration in n -adic datasets [9], which, to the best of our knowledge, is a feature that is not included in any other tool. This was implemented using answer set programming (ASP), a logic programming approach, and is an intuitive way to explore your data even for non-technical users as it can be seen in Figure 2.

Another new feature of **FCA Tools Bundle** is displaying formal concepts in weak analogical proportions. Analogical proportion ([5–7]) is a key pattern which is associated with the idea of analogical reasoning and represents a statement between two pairs (A, B) and (C, D) of the form A is to B as C is to D where all elements A, B, C, D are in the same category. Analogical proportions can be formulated for numbers, sets, in the boolean case, strings, as well as in various algebraic structures, like semigroups or lattices. As explained in a previous paper [11], if we denote by O_x and A_x the extent, respectively the intent of concept x , then, by the main theorem of FCA, we have that four elements (x, y, z, t) of a lattice are in a *Weak Analogical Proportion (WAP)* iff

$$A_x \cap A_t = A_y \cap A_z \text{ and } O_x \cap O_t = O_y \cap O_z.$$

When selecting a WAP from a list in **FCA Tools Bundle** the formal concepts which are part of the WAP are highlighted as in Figure 3. This feature can be

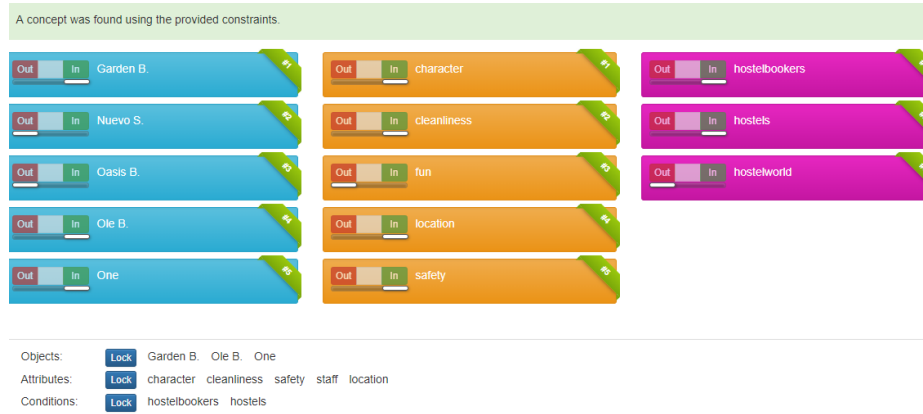


Fig. 2: Constraint based concept exploration

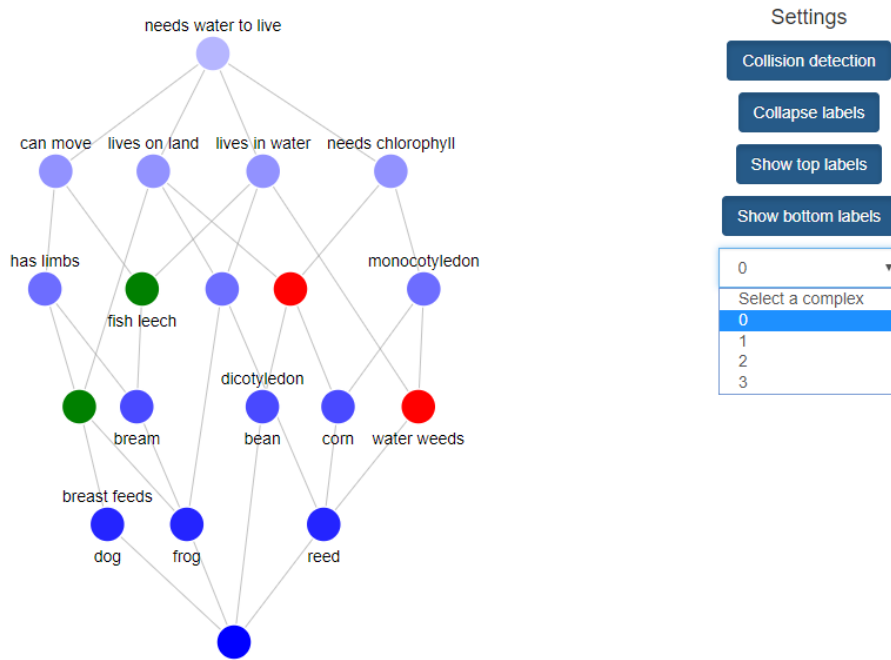


Fig. 3: Visualizing analogical proportions in a concept lattice

very useful since it is interesting to find relations between concepts that are not directly linked in a concept lattice. The computation is done by using an ASP algorithm proposed by Miclet et. al [6].

4 Conclusions and Future Work

In this paper we have presented the features integrated in `FCA Tools Bundle`, a platform which aims to offer a comprehensive range of FCA features accessible not only to FCA experts, but also to users outside the FCA community. We believe that `FCA Tools Bundle` is an important progress towards a self contained FCA platform, by implementing functionalities such as visualization and navigation in dyadic and n -adic datasets including some features which, to the best of our knowledge, are not present in any other tool.

For the future we plan to integrate in the `FCA Tools Bundle` more features of FCA that would allow an enhanced data analysis, such as computing implications and pattern structures.

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