Abstraction, taxonomies, connectivity : from AI to FCA and back

Henry Soldano

Université Paris 13, Sorbonne Paris Cité, L.I.P.N UMR-CNRS 7030
F-93430, Villetaneuse, France

Abstract. We describe an experience of transfer and ideas exchange between AI and FCA. The original motivation was a data analysis problem in which there were objects, structured attributes together with a categorization of objects, leading to the idea that in some way the categorization should alter the selection of interesting patterns. On one hand, soon it appeared that to investigate the data it was interesting to use various degrees of coarseness not only on the pattern language but also on the extensions, i.e. the support, following the data mining terminology, of the patterns. On an other hand, closed patterns are known to summarize the whole set of frequent patterns, and FCA proposes to organize these closed patterns into a concept lattice, each node of which was a pair made of a closed pattern and its extension, but there were no known way to use categorization and relative coarseness in a flexible way. On the FCA technical side, this led us in particular to extend concept lattices to smaller conceptual structures, called abstract concept lattices, in which the extension of a term/motif/pattern in a set of objects is constrained by an external a priori view of the data together with a parameter controlling the degree of coarseness [1,2]. A closer view to the structure of the corresponding extensional space led us back to AI : we called such a structure an abstraction as it captured part of the notion of domain abstraction as it has been investigated in AI [3]. The most interesting transfer back to AI relied on the following observation : the set of abstract implications related to these abstract lattices had a particular meaning that was naturally expressed in modal logics. A direct consequence is that the notion of abstraction necessary to preserve the lattice structure of closed patterns, i.e. to preserve the concept lattice structure, defined a particular class of modal logics, we called modal logics of abstraction, whose properties led to a new kind of semantics [4]. In few words, in such a modal logics the modal connector, usually known as a "necessity" connector and represented as a square, could be translated as an "abstraction" operator, i.e. a sentence as "□ P" was understood as "Abstractly P". The corresponding semantics relied on a covering of the universe, and could not, except in particular cases, be translated as the standard "possible world" semantics of the most common modal logics.

More recently, new trends in AI and data mining orient research towards linked data. The same formal notion of abstraction can be defined on graphs, and this leads to a way to extract closed patterns from graphs whose vertices are objects described in a FCA framework, therefore allowing to investigate attributed graphs [5]. Finally, recent work on data mining discuss closure operators on partially ordered pattern languages weaker than lattices, as the set of connected subgraphs of some graph, which leads to extend formal concept analysis beyond the lattice

structure still preserving a large part of the nice formal structures and results of FCA[6].

References

1. Pernelle, N., Rousset, M.C., Soldano, H., Ventos, V.: Zoom: a nested Galois lattices-based system for conceptual clustering. J. of Experimental and Theoretical Artificial Intelligence **2/3**(14) (2002) 157–187
2. Ventos, V., Soldano, H.: Alpha Galois lattices: An overview. In Ganter, B., (Eds), R.G., eds.: International Conference on Formal Concept Analysis (ICFCA). Volume 3403 of Lecture Notes on Computer Science. Springer Verlag (2005) 298–313
3. Soldano, H., Ventos, V.: Abstract Concept Lattices. In Valtchev, P., Jäschke, R., eds.: International Conference on Formal Concept Analysis (ICFCA). Volume 6628 of LNAI., Springer, Heidelberg (2011) 235–250
4. Soldano, H.: A modal view on abstract learning and reasoning. In Genesereth, M., Revesz, P.Z., eds.: Ninth Symposium on Abstraction, Reformulation, and Approximation, SARA 2011, Cardona, Catalonia, SPAIN, AAAI Press (July 2011) 99–106
5. Soldano, H., Santini, G.: Graph abstraction for closed pattern mining in attributed network. In: European Conference in Artificial Intelligence (ECAI), IOS Press (2014) to appear
6. Soldano, H.: Closed patterns and abstraction beyond lattices. In Glodeanu, C., Kaytoue, M., Sacarea, C., eds.: International Conference on Formal Concept Analysis (ICFCA). Volume 8478 of LNAI., Springer, Heidelberg (2014) to appear