

# A Fixed Point Theorem for Stronger Association Rules and Its Computational Aspects\*

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## Abstract

Each relation induces a new closure operator, which is (in the sense of data mining) stronger than or equal to the Galois one. The goal is to give some evidence that the new closure operator is often properly stronger than the Galois one. An easy characterization of the new closure operator as a largest fixed point of an appropriate contraction map leads to a (modest) computer program. Finally, various experimental results obtained by this program give the desired evidence.

**Keywords:** Association rule, database, data mining, lattice, poset, context, concept lattice, formal concept analysis, Galois connection, functional dependency.

## 1 Introduction to a new closure operator

Although the terminology of formal concept analysis is frequently used in the first two sections, the paper belongs neither to formal concept analysis nor to other applied fields about data bases. These fields are used only as a part of motivations of the present study. However, in the converse direction, there is some hope that this section and mainly the next one may give some motivation to these fields. This section is devoted only to definitions and some basic properties; our motivations will be given in the next section.

Following Wille's terminology, cf. [11] or [7], a triplet

$$(A^{(0)}, A^{(1)}, \rho)$$

is called a *context* if  $A^{(0)}$  and  $A^{(1)}$  are nonempty sets and  $\rho \subseteq A^{(0)} \times A^{(1)}$  is a binary relation. From what follows, we fix a context  $(A^{(0)}, A^{(1)}, \rho)$  and let

$$\rho_0 = \rho \text{ and } \rho_1 = \rho^{-1}.$$

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