Chapter 3
Constructing Galois Lattices as a Commonsense Reasoning Process

Xenia Naidenova
Military Medical Academy, Russia

ABSTRACT

The concept of good classification test is used in this chapter as a dual element of the interconnected algebraic lattices. The operations of lattice generation take their interpretations in human mental acts. Inferring the chains of dual lattice elements ordered by the inclusion relation lies in the foundation of generating good classification tests. The concept of an inductive transition from one element of a chain to its nearest element in the lattice is determined. The special reasoning rules for realizing inductive transitions are formed. The concepts of admissible and essential values (objects) are introduced. Searching for admissible and essential values (objects) as a part of reasoning is based on the inductive diagnostic rules. Next, the chapter discusses the relations between constructing good tests and the Formal Concept Analysis (FCA). The decomposition of inferring good classification tests is advanced into two kinds of subtasks that are in accordance with human mental acts. This decomposition allows modeling incremental inductive-deductive inferences. The problems of creating an integrative inductive-deductive model of commonsense reasoning are discussed in the last section of this chapter.

THE RULES OF THE FIRST TYPE IN THE FORM OF "IF–THEN" ASSERTIONS

In this chapter we describe a model of commonsense reasoning that has been acquired from our numerous investigations on the human reasoning modes used by experts for solving diagnostic problems in diverse areas such as pattern recognition of natural objects (rocks, ore deposits, types of trees, types of clouds etc.), analysis of multi-spectral information, image processing, interpretation of psychological testing data, medicine diagnosis and so on. The principal aspects of this model coincide with the rule-based inference mechanism having been embodied in the KADS system (Ericson, et al., 1992), (Gappa, & Poeck, 1992). More details related to our model of reasoning and its imple-

DOI: 10.4018/978-1-4666-1900-5.ch003

mentation can be found in (Naidenova, & Syrbu, 1984; Naidenova, & Polegaeva, 1985a; 1985b).

An expert's rules are logical assertions that describe the knowledge of specialists about a problem domain. Our experience in knowledge elicitation from experts allowed us to capture the typical forms of assertions used by experts. Practically without loss of knowledge, an expert's assertions can be represented with the use of only one class of logical rules, namely, the rules based on implicative dependencies between names.

We need the following three types of rules in order to realize logical inference (deductive and inductive):

Instances or relationships between objects or facts really observed. Instance can be considered as a logical rule with the least degree of generalization. On the other hand, instances can serve as a source of a training set of positive and negative examples for generalized rules' inductive inferring.

Rules of the first type or logical rules. These rules describe regular relationships between objects and their properties and between properties of different objects. The rules of the first type can be given explicitly by an expert or derived automatically from examples with the help of a learning process. These rules are represented in the form "if-then" assertions.

Rules of the second type (commonsense reasoning rules) embrace both inductive and deductive reasoning rules with the help of which rules of the first type are used, updated, and inferred from data (instances).

THE RULES OF THE FIRST TYPE AS A LANGUAGE FOR KNOWLEDGE

The rules of the first type can be represented with the use of only one class of logical statements based on implicative dependencies between names. Names are used for designating concepts, things, events, situations, or any evidences. They can be considered as attributes' values in the formal representations of logical rules. In sequel, the letters a, b, c, d, … will be used as attributes' values in logical rules and the letters A, B, C, D,.. will be used as items in database transactions. We consider the following rules of the first type.

Implication: $a, b, c \rightarrow d$. This rule means that if the values standing on the left side of the rule are simultaneously true, then the value on the right side of the rule is always true.

One may find a lot of examples of using the first type rules in our every day life but these rules are revealed very distinctly in detective stories. We preferred to draw the examples from Sherlock Holmes's practice because he was "the most perfect reasoning and observing machine that the world have seen" in Doctor Watson's opinion. Here is a typical example of Sherlock Holmes's reasoning (Doyle, 1992): "As to your practice, if a gentleman walks into my room smelling of iodoform, with a black mark of nitrate of silver upon his right fore-finger, and a bulge on the side of top-hat to show where he has secreted his stethoscope, I must be dull indeed, if I do not pronounce him to be an active member of the medical profession."

Interdiction or Forbidden Rule: (a special case of implication): $a, b, c \rightarrow$ *false* (*never*). This rule interdicts a combination of values enumerated on the left side of the rule. The rule of interdiction can be transformed into several implications such as $a, b \rightarrow$ not c; $a, c \rightarrow$ not b; $b, c \rightarrow$ not a.

As a forbidden rule, we can quote the famous assertion of the Great Russian poet A. Pushkin: "Genius and violence are incompatible".

Compatibility: $a, b, c \rightarrow VA$, where VA is the frequency of occurrence of the rule. The compatibility is equivalent to the collection of implications as follows: $a, b \rightarrow c, VA$; $a, c \rightarrow b, VA$; $b, \text{c} \rightarrow b, VA$. Experts in many research areas use this rule to show