Chapter 8
The Duality of Good Diagnostic Tests

ABSTRACT

The concept of good classification test is redefined in this chapter as a dual element of 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 or essential values (objects) as a part of reasoning is based on the inductive diagnostic rules. In this chapter, we also propose a non-incremental learning algorithm NIAGaRa based on a reasoning process realizing one of the ways of lattice generation. Next, we discuss the relations between the good test construction and the Formal Concept Analysis (FCA).

INTRODUCTION

We redefine the concept of the good classification test as a dual element of interconnected algebraic lattices. The process of lattice construction is considered as a knowledge elicitation or commonsense reasoning process. 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 all the kinds of good classification tests. We introduce the concept of an inductive transition from one element of a chain to its nearest element in the lattice. Four possible variants of induction

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transitions are considered. The special reasoning rules realizing the inductive transitions are introduced: the rules of generalization and specification and their dual variants.

Note that reasoning begins with using a mechanism for restricting the space of searching for tests: 1) for each collection of attributes’ values (objects), to avoid constructing all its subsets, 2) for each step of reasoning, to choose a collection of attributes’ values (objects) without which good tests can not be constructed. For this goal, admissible values (objects) and essential values (objects) are determined. Searching for admissible or essential values (objects) is based on inductive diagnostic rules. These rules, on the one hand, realize the inductive Method of Difference (Mill, 1872); on the other hand, they give rise to diagnostic assertions involved immediately in the processes of good tests construction.

Under lattice construction, the deductive rules of the first type, namely, implications, interdictions, rules of compatibility (approximate implications), and diagnostic assertions are generated and used immediately. Hence the deductive reasoning rules (rules of the second type) are naturally drawn into inductive reasoning for pruning the search space. The detailed analysis of algorithms of searching for all GDTs in terms of constructing the algebraic lattice allowed us not only to determine the structure of inferences but also to decompose algorithms into sub-problems and operations that represent known deductive and inductive modes (modus operandi) of commonsense reasoning. Thus the class of symbolic machine learning algorithms can be transformed into the process of integral reasoning, where different rules (deductive, inductive, abductive, traductive, etc.) alternate and support each other. These are mental acts that can be found in any reasoning: stating new propositions, choosing the relevant part of knowledge and/or data for further steps of reasoning, involving a new rule of reasoning (deductive, abductive, inductive, traductive, etc.).

In this chapter, we also propose a non-incremental learning algorithm NIAGaRa based on one of the possible variants of generalization inductive reasoning rule. This algorithm generates all the GMRTs for a given sets of positive and negative examples. Next we discuss some of current works related to concept lattice construction.

**CORRESPONDENCE OF GALOIS FOR GOOD CLASSIFICATION TEST DEFINITION**

Let \( S = \{1, 2, \ldots, N\} \) be the set of objects’ indices (objects, for short) and \( T = \{A_1, A_2, \ldots, A_j, \ldots, A_m\} \) be the set of attributes’ values (values, for short). Each object is described by a collection of values from \( T \).

The definition of good tests is based on correspondences of Galois \( G \) on \( S \times T \) and two relations \( S \rightarrow T, T \rightarrow S \) (Ore, 1944; Riguet, 1948; Everett, 1944). Let \( s \subseteq S, t \subseteq T \). Denote by \( t_i, t_i \subseteq T, i = 1, \ldots, N \) the description of object with index \( i \). We define the relations \( S \rightarrow T, T \rightarrow S \) as follows:

\[ S \rightarrow T: t = \text{val}(s) = \{\text{intersection of all } t; t_i \subseteq t, i \in s\} \]

\[ T \rightarrow S: s = \text{obj}(t) = \{i: i \in S, t \subseteq t_i\}. \]

Of course, we have \( \text{obj}(t) = \{\text{intersection of all } s(A): s(A) \subseteq S, A \in t\} \). Operations \( \text{val}(s), \text{obj}(t) \) are reasoning operations related to discovering the general feature of objects the indices of which belong to \( s \) and to discovering the indices of all objects possessing the feature \( t \).
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