

# Preface

Reasoning about incomplete and inconsistent information (also imprecise, para-complete information) is an important subject in the fields of mathematics, philosophy, computer science, and Artificial Intelligence. To formalize such reasoning, *logic* plays an important role. This is because logic can precisely represent information and can derive useful information from given information as inferences.

Here, by logic we normally mean *classical logic*. It is known that classical logic is well established in the sense that its foundations, namely proof and model theory, have been fully studied. In addition, a lot of work on *automated theorem-proving* for classical logic has been done. The development of theorem-proving techniques has led to *logic programming* like Prolog.

However, classical logic is not suited to formalize incomplete and inconsistent information in our world. For instance, human reasoning is done based on incomplete and inconsistent information and involves some intensional concepts like knowledge, belief, and time. To overcome shortcomings of classical logic, various *nonclassical logics* have been proposed. They include modal logic, epistemic logic, tense logic, and others.

*Annotated logics* are systems of nonclassical logics for reasoning about incomplete and inconsistent information, originally proposed by Subrahmanian [149] as a foundation for *paraconsistent logic programming*. Later, da Costa et al. [62, 66] worked out formal aspects of annotated logics; also see Abe [1]. Since annotated logics were designed as a framework of reasoning about incomplete and inconsistent information, they can also be expanded for describing various types of common-sense reasoning.

We can view annotated logics as interesting systems of *paraconsistent logics*, which are logical systems for inconsistent, but nontrivial theories. Thus, annotated logics should be formally studied. In addition, there is a rich variety of applications of annotated logics.

This book is written as an introduction to annotated logics. The main objective is to provide logical foundations for annotated logics. We also discuss some interesting applications of these logics. The book includes the authors' contributions to annotated logics.

The structure of the book is as follows:

Chapter 1 gives motivations and the history of annotated logics as an introduction to this book. First, we discuss the importance of annotated logics in connection with paraconsistent logics. Second, we present the history of annotated logics by reviewing the literature on the subject.

Chapter 2 introduces the propositional annotated logics  $P\tau$ . We present a Hilbert style axiomatization of  $P\tau$  and their semantics. We show some formal results including completeness.

Chapter 3 studies the predicate annotated logics  $Q\tau$ , which can be seen as a predicate extension of  $P\tau$ . Their axiomatization and semantics are considered. We also prove completeness and other metatheorems.

Chapter 4 discusses formal issues of annotated logics. We describe an algebraic semantics for  $P\tau$  based on Curry algebras. We also discuss annotated set theory, annotated model theory, proof methods, and annotated modal logics.

Chapter 5 reviews some variants of annotated logics and related systems in the literature. Variants include fuzzy annotated logics, possibilistic annotated logics, inductive annotated logics, and structural annotated logics. We also compare annotated logics with related systems such as Labelled Deductive Systems and General Logics. Finally, we review systems of paraconsistent logics.

Chapter 6 discusses applications of annotated logics for various areas. After reviewing paraconsistent logic programming and generalized annotated logic programming, we survey promising applications to knowledge representation, neural computing, automation, and robotics.

Chapter 7 gives some conclusions with the summary of the book. It is possible to conclude that annotated logics are very interesting theoretically as well as practically. However, there are some future problems to be worked out.

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