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Towards Paraconsistent Engineering

Springer

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Foreword

In classical and in most non-classical logics, if a theory T is inconsistent, i.e., contains contradictory theorems, then it is also trivial; T is said to be trivial if any sentence of its language is provable in T. A theory founded on a paraconsistent logic may be inconsistent but non-trivial. So, we are able, with the help of such a logic, to develop inconsistent but non-trivial theories.

Paraconsistent logics can be conceived as logics that are rival of classical logic or as formal tools that may complement classical logic in certain situations.

One relevant point is that paraconsistent logics did find an extraordinary number of applications, which constitute the basis of applied paraconsistency. Leaving aside philosophy, law, and the foundations of science, paraconsistent logic came to be significant in domains like the following:

- Computer science:

  Artificial Intelligence (common sense reasoning, knowledge representation)
  Database, knowledge bases
  Data mining
  Conceptual analysis
  Software engineering

- Engineering:

  Signal processing (sound processing, image processing)
  Neural computing
  Intelligent control
  Robotics
  Traffic control in large cities

- Economics:

  Decision theory
  Game theory
  Finances

- Linguistics:

  Formal semantics
  Computational linguistics

Jair Minoro Abe was one of my best Ph.D. students at the University of São Paulo in the eighties of the last century. At that time, we did not know a large number of real and good applications of paraconsistent logic (envisaged as a rival of or as a complement to classical logic). Since the beginning of his Ph.D. work, Abe became interested in the possible applications of paraconsistent logic. He was, above all, one of the pioneers of this domain, little by little opening new ways, particularly in paraconsistent robotics, decision theory, and neural nets. After his contact with the Japanese logicians Seiki Akama and Kazumi Nakamatsu, the progress in the area of applications became wide and profound. In all applications involving a large part of technology, Abe, Akama, Nakamatsu, and collaborators employed paraconsistent logic as an instrument to cope with special and significant problems.

This book, dedicated to Jair Minoro Abe on the occasion of his 60th birthday, shows, at least in outline, a small part of what has been done in the field of applications of paraconsistency. On the other hand, it also makes clear how relevant and productive may be the collaboration between the experts of two distant countries, in this case Brazil and Japan.

Most papers collected in this book are related to applied paraconsistency. Moreover, all of them are dedicated to Jair Minoro Abe, the friend, the man, and the logician.

Curitiba, Brazil
January 2016

Newton C.A. da Costa

Preface

Paraconsistent logics refer to non-classical logical systems, which can properly handle contradictions. They can overcome defects of classical logic. Initially, they were motivated by philosophical and mathematical studies, but they recently received interesting applications to various areas including engineering. To tolerate contradictions is an important problem in information systems, and paraconsistent logics can provide suitable answers to it. Paraconsistent engineering, which is engineering based on paraconsistent logics, should be developed to improve current approaches. Jair Minoro Abe is one of the experts on Paraconsistent Engineering, who developed the so-called annotated logics. This book collects papers by leading researchers, which discuss various aspects of paraconsistent logics and related logics. It includes important contributions on foundations and applications of paraconsistent logics in connection with engineering, mathematical logic, philosophical logic, computer science, physics, economics, and biology. It will be of interest to students and researchers, who are working on engineering and logic. The structure of this book is as follows.

Chapter 1 by S. Akama gives an introduction to this book.

Chapter 2 by S. Akama and N.C.A. da Costa discusses the reason why paraconsistent logics are very useful to engineering. In fact, the use of paraconsistent logics is a starting point of Abe's work. The ideas and history of paraconsistent logics are reviewed. The chapter is also useful for readers to read papers in this book.

Chapter 3 by N.C.A. da Costa and D. Krause is concerned with an application of a paraconsistent logic to quantum physics. The paper reviews the authors' previous papers on the concept of complementarity introduced by Bohr. Logical foundations for quantum mechanics have been worked out so far. The paper reveals that the authors' paraconsistent logic can serve as the basis for the important problem in quantum mechanics.

Chapter 4 by J.-Y. Beziau proposes two three-valued paraconsistent logics, which are 'genuine' in the sense that they obey neither $p, \neg p \vdash q$ nor $\vdash \neg(p \wedge \neg p)$. Beziau investigates their properties and relations to other paraconsistent logics. His work is seen as a new approach to three-valued paraconsistent logics.

Chapter 5 by S. Akama surveys *annotated logics* which have been developed as paraconsistent and paracomplete logics by Abe and others. The paper presents the formal and practical aspects of annotated logics and suggests their further applications for paraconsistent engineering.

Chapter 6 by J.I. da Silva Filho et al. discusses an application of the annotated logic called *PAL2v* based on two truth-values for *paraconsistent artificial neural network* (PANet), showing an algorithmic structure for handling actual problems. The paper is one of the interesting engineering applications of paraconsistent logic.

Chapter 7 by K. Nakamatsu and S. Akama is concerned with *annotated logic programming*. Indeed, the starting point of annotated logics is paraconsistent logic programming, but the subject has been later expanded in various ways. Annotated logic programming can be considered as a tool for many applications. In this paper, they present several approaches to annotated logic programming.

Chapter 8 by Y. Kudo et al. reviews *rough set theory* in connection with modal logic. Rough set theory can serve as a basis for granularity computing and can be applied to deal with many problems in intelligent systems. It is well known that there are some connections between rough set theory and modal logic.

Chapter 9 by T. Murai et al. investigates paraconsistency and paracompleteness in Chellas's conditional logic using Scott–Montague semantics. It is possible to express inconsistency and incompleteness in conditional logic, and they provide several formal results.

Chapter 10 by F.A. Doria and C.A. Cosenza presents a logical approach to the so-called *efficient market* which means that stock prices fully reflect all available information in the market. They introduce the concept of almost efficient market and study its formal properties.

Chapter 11 by J.-M. Alliot et al. is about a logic called the *molecular interaction logic* to represent temporal reasoning in biological systems. The logic can semantically characterize *molecular interaction maps* (MIM) and formalize various reasoning on MIM.

Chapter 12 by S. Akama summarizes Abe's work on paraconsistent logics and their applications to engineering and surveys some of his projects shortly. The paper clarifies his ideas on paraconsistent engineering.

Most papers in this book are related to paraconsistent logics, and they tackle various problems by using paraconsistent logics. The book is dedicated to Jair Minoro Abe for his 60th birthday. I am grateful to contributors and referees.

Kawasaki, Japan Seiki Akama
May 2016

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