Chapter 9
On Localities of Knowledge Inconsistency

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ABSTRACT
Inconsistency is commonplace in the real world in long-term memory and knowledge based systems. Managing inconsistency is considered a hallmark of the plasticity of human intelligence. Belief revision is an important mental process that underpins human intelligence. To facilitate belief revision, it is necessary to know the localities and contexts of inconsistency and how different types of inconsistency are clustered. In this paper, the author provides a formal definition of locality of inconsistency and describes how to identify clusters of inconsistent circumstances in a knowledge base. The results pave the way for a disciplined approach to manage knowledge inconsistency.

1. INTRODUCTION
Inconsistency is ubiquitous in the real world, in our long-term memory, and in knowledge based systems. Inconsistency manifests itself in a plethora of phenomena ranging from expertise, meta-knowledge, knowledge, information, to data. Managing inconsistency is considered an accepted part of life (Gotesky, 1968). As observed in (Shastri & Grannes, 1996), “we often hold inconsistent beliefs in our long-term memory without being explicitly aware of such inconsistencies. But at the same time, we often recognize contradictions in our beliefs when we try to bring inconsistent knowledge to bear on a particular task.” From human psychological perspective, when confronted with an inconsistent circumstance, an individual attempts to reason from inconsistency to consistency (Johnson-Laird et al., 2004). The model theory of reasoning to consistency suggests that

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the mental processes consist of three components: inconsistency detection, belief revision, and inconsistency resolution through explanation (Johnson-Laird et al., 2004).

Managing inconsistency is a hallmark of the plasticity of human intelligence. Central to this is the concept of cognitive penetrability introduced by Zenon Pylyshyn (1989): the pattern of behavior can be altered in a rational way by changing subjects’ beliefs about the task. The plasticity of human intelligence lies in the fact that many mental processes dealing with sensation, cognition, perception, emotion, action, and interaction are cognitively penetrable: the knowledge, beliefs, goals and expectations a person possesses could influence the experience, behaviors and consequent judgments the person has in those mental processes.

If a system is cognitively penetrable then the function it computes is sensitive, in a semantically coherent way, to the organism’s goals, beliefs and expectations, in other words, the function can be altered in a way that bears some logical relation to what the system knows (Pylyshyn, 1999). As exhibited in the natural cognitive systems, human beings can revise their goals, beliefs, expectations, and plans in the face of fresh evidence or as a result of inferences which update previously held beliefs.

When an individual is forced to revise beliefs in the presence of an inconsistency, a long-standing hypothesis is that a minimal change should be made to the previously held beliefs so as to accommodate the fresh evidence (Johnson-Laird et al., 2004). To do so, a necessary condition is that we need to know the localities and contexts of inconsistency, and how different types of inconsistency are clustered.

This paper is an extension to our early results (Zhang, 2010a). Our focus is on a formal definition of locality of inconsistency at knowledge level and on how to utilize this definition to identify clusters of inconsistent circumstances in a knowledge base system. We use locality of inconsistency as a tool to separate relevant and contributing cognitions from irrelevant ones with regard to a particular inconsistent circumstance, and to provide support for chunking inconsistent knowledge into refined and manageable sizes.

The rest of the paper is organized as follows. We briefly review in Section 2 different types of knowledge inconsistency. Section 3 provides a brief recap of the fixpoint semantics for knowledge bases, which we rely on later when dealing with the issue of capturing localities of inconsistency. In Section 4, we offer a formal definition of locality of inconsistency in terms of a concept called antagonistic cognitive distance. We describe four algorithms in Section 5 on how to identify localities for four different types of inconsistency. Finally we conclude the paper in Section 6 with remark on future work.

2. KNOWLEDGE INCONSISTENCY TYPES

Since the process of identifying locality of inconsistency will be affected by various types of inconsistency to be encountered, it is necessary to know how many types of knowledge inconsistency we need to deal with. In our previous work, we have identified the following twelve types of inconsistency (Zhang, 2008, 2009, 2010b) which are briefly summarized as follows.

1. Complementary inconsistency refers to an atom and its negation.
2. Mutually exclusive inconsistency stems from mutually exclusive predicates that are syntactically different and semantically opposite of each other (see an example later in Sections 4 and 5).
3. Incompatible inconsistency is caused by having an atom and the negation of its syntactically different but logically equivalent relation (synonymous predicate).