Reconsideration on Non-Linear Base Orderings

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Abstract. Reconsideration is a belief change operation that re-optimizes a finite belief base following a series of belief change operations—provided all base beliefs have a linear credibility ordering. This paper shows that linearity is not *required* for reconsideration to improve and possibly optimize a belief base.

Keywords. Base belief change, knowledge base optimization, reconsideration

Reconsideration, as defined in [2] (and discussed in [3] in these proceedings), re-optimizes a finite belief base in an implemented system following a series of belief change operations, provided the base beliefs have a linear credibility ordering; but ordering *all* the base beliefs in a knowledge system is impractical. This paper shows that linearity is not *required* for reconsideration to improve and possibly optimize a belief base.[1]

A belief *base*, for implementation purposes, is a finite set of core (or base) beliefs that are input to the system. Any implemented system that can perform expansion (adding a new belief to the base) and consolidation (removing beliefs from the base to restore consistency [1]) can perform reconsideration.

We define the minimally inconsistent subsets of a base B as *NAND-sets*; a NAND-set that is a subset of the current base is called *active* and makes that base inconsistent. Consolidation of B (written $B!$) uses a decision function to select the base beliefs (called culprits) to be removed (unasserted). In addition to (and assumed to be consistent with) any pre-existing credibility ordering, the selected culprits are considered strictly weaker than other members of their NAND-sets that were *not* removed. The system must store all base beliefs (asserted and unasserted) in a set called $B^{\cup}$ in order to perform reconsideration, which is the consolidation of all base beliefs ($B^{\cup}!$) and is independent of the current B. An unasserted culprit is *JustifiedOut* if its return raises an inconsistency that can be resolved only by removing either that culprit or some *stronger* belief.

We define an optimal base by assuming a consistent base is preferred over any of its proper subsets and a belief p is preferred over multiple beliefs (e.g., q, v) that are strictly weaker than p: $p \succ q; p \succ v; \therefore \{p\} \succ \{q, v\}$. If the pre-order defines a *least element* for all NAND-sets, the following algorithm yields an optimal base. Let B be the set of all non-culprit base beliefs in $B^{\cup}$. For each culprit p (in non-increasing order of credibility): if p is *not* JustifiedOut, reset $B \leftarrow B \cup p$. After each pass through the for-loop:

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[1]See [2] (or [3]) for a detailed (or brief) discussion of the benefits of reconsideration.

Table showing a base, B, revised by $\neg a$ (.95), then revised by a (.98), and then after Reconsideration is performed. Columns show different adjustment strategies producing varied results for revision and reconsideration.							
Belief Base	Degree	Standard	Maxi-adjustment	Hybrid	Global	Linear	Quick
B	.95	$a \vee b$	$a \vee b$	$a \vee b$	$a \vee b$	$a \vee b$	$a \vee b$
	.90	$a \vee f$	$a \vee f$	$a \vee f$	$a \vee f$	$a \vee f$	$a \vee f$
	.40	$a \vee d$, $\neg b \vee \neg d$, d, e, f	$a \vee d$, $\neg b \vee \neg d$, d, e, f	$a \vee d$, $\neg b \vee \neg d$, d, e, f	$a \vee d$, $\neg b \vee \neg d$, d, e, f	$a \vee d$, $\neg b \vee \neg d$, d, e, f	$a \vee d$, $\neg b \vee \neg d$, d, e, f
	.20	$\neg g \vee \neg b$, $\neg d \vee g$	$\neg g \vee \neg b$, $\neg d \vee g$	$\neg g \vee \neg b$, $\neg d \vee g$	$\neg g \vee \neg b$, $\neg d \vee g$	$\neg g \vee \neg b$, $\neg d \vee g$	$\neg g \vee \neg b$, $\neg d \vee g$
$(B + \neg a)!$	.95	$\neg a$, $a \vee b$	$\neg a$, $a \vee b$	$\neg a$, $a \vee b$	$\neg a$, $a \vee b$	$\neg a$, $a \vee b$	$\neg a$, $a \vee b$
	.90	$a \vee f$	$a \vee f$	$a \vee f$	$a \vee f$	$a \vee f$	$a \vee f$
	.40	f	e, f	$\neg b \vee \neg d$, e, f	e, f		d, e, f
	.20		$\neg g \vee \neg b$, $\neg d \vee g$	$\neg g \vee \neg b$, $\neg d \vee g$		$\neg g \vee \neg b$, $\neg d \vee g$	
$((B + \neg a)! + a)!$	.98	a	a	a	a	a	a
	.95	$a \vee b$	$a \vee b$	$a \vee b$	$a \vee b$		$a \vee b$
	.90	$a \vee f$	$a \vee f$	$a \vee f$	$a \vee f$	$a \vee f$	$a \vee f$
	.40		e, f	$\neg b \vee \neg d$, e, f	e, f		d, e, f
	.20		$\neg g \vee \neg b$, $\neg d \vee g$	$\neg g \vee \neg b$, $\neg d \vee g$		$\neg g \vee \neg b$, $\neg d \vee g$	
$((B + \neg a) + a)!$	.98	a (improved)	a (optimal)	a (optimal)	a (unchanged)	a (improved)	a (optimal)
	.95	$a \vee b$	$a \vee b$	$a \vee b$	$a \vee b$		$a \vee b$
	.90	$a \vee f$	$a \vee f$	$a \vee f$	$a \vee f$	$a \vee f$	$a \vee f$
Reconsideration	.40	$a \vee d$	$a \vee d$, $\neg b \vee \neg d$, d, e, f	$a \vee d$, $\neg b \vee \neg d$, d, e, f	e, f	$a \vee d$, $\neg b \vee \neg d$, d, e, f	$a \vee d$, $\neg b \vee \neg d$, d, e, f
	.20		$\neg g \vee \neg b$, $\neg d \vee g$	$\neg g \vee \neg b$, $\neg d \vee g$		$\neg g \vee \neg b$, $\neg d \vee g$	$\neg g \vee \neg b$, $\neg d \vee g$

Table 1. This table shows revision and reconsideration on a total pre-order of beliefs using six different adjustment strategies (as implemented in SATEN[4]). For a full discussion, cf. [2].

1. if q is a culprit and $q \succ p$, q was processed during an earlier pass;
2. all NAND-sets with p as a least element are *not* active and will remain so through the end of the algorithm;
3. if p is JustifiedOut, it will remain so through the end of the algorithm.

When the loop exits, we know that:

- all unasserted culprits are JustifiedOut;
- the resultant base, B, is consistent (no NAND-set is active);
- the resultant base, B, is optimal ($\forall B' \subseteq B^{\cup} : B' \neq B \Rightarrow B \succ B'$).

When the minimal beliefs of a NAND-set number more than one, base optimality is harder to define, but reconsideration can still help improve a base (possibly to a clearly optimal state). Table 1 shows reconsideration on a total pre-order for six different decision functions implemented in SATEN [4]. Five bases improved—three to optimal.

Systems with non-linear credibility orderings can benefit from implementing reconsideration. We have implemented an anytime, interleavable algorithm for reconsideration in an existing reasoning system (cf. [2]).

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