Knowledge Base Update Methods

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References

1. Alchourrn, C.E., Gardenfors, P., Makinson, D.: On the logic theory change: Partial meet contraction and revision functions. Journal of Symbolic Logic 50 (1985) 510-530.
2. Katsuno, H., Mendelzon, A.O.: On the difference between updating a knowledge base and revising it. In: Proceedings of the 2nd International Conference on Principles of Knowledge Representation and Reasoning. (1991) 387–394.
3. M. Winslett. Reasoning about Action Using a Possible Model Approach. In: *Proc. AAAI-88*, St. Paul, MN, 1988, 89-93.
4. M. Winslett. Updating Logical Databases. In: D. Gabbay, A. Galton, J. A. Robinson (eds.). *Handbook of Logic in Artificial Intelligence and Logic Programming*. Vol. 4 (Epistemic and Temporal Reasoning), 1995, Oxford University Press, 133-174.

References

5. A. Herzig. The PMA Revisited. In: *Proc. of the 5th Int'l. Conference on Principles of Knowledge Representation and Reasoning*, Morgan Kaufmann, 1996, 40-50.
6. Doherty, P., ukaszewicz, W., Madalinska-Bugaj, E.: The PMA and relativizing minimal change for action update. Fundamenta Informaticae **44** (2000) 95–131.
7. W. Łukaszewicz, E. Madalińska-Bugaj. Reasoning about Action and Change Using Dijkstra's Semantics for Programming Languages: Preliminary Report. *Proceedings of 14th International Joint Conference on Artificial Intelligence*, 1995, 1950-1955.
8. R. Reiter. Knowledge in Action: Logical Foundation in Specifying and Implementing Dynamical Systems, The MIT Press, 2001.

The problem description

Notation 1

- KB – knowledge base – a set of classical logic formulae or their conjunction
- α – a formula – a new observation of the world under consideration

What is a new KB, written KB' ?

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3. And if they are inconsistent? Go INC

Example 1

$KB = p \wedge (q \vee s)$, $\alpha = p \wedge \neg t$

KB knows nothing about t and knows the same about p as α then there is no conflict and $KB' \equiv p \wedge \neg t \wedge (q \vee s)$ is intuitive.

Go Return

Example 2

$KB = \neg p$ and $\alpha = p \vee q$

KB and α are consistent but $KB \wedge \alpha \equiv \neg p \wedge q$

This formula does not seem to be that we should expect. KB' should be rather $p \vee q$.

As we see, some more detailed assumptions are necessary.

Example 3

Consider the following situation.

There is exactly one person in the room – Alice or Bob, but we don't know which one of them.

Thus, KB contains a formula

$$(RA \wedge \neg RB) \vee (RB \wedge \neg RA).$$

Consider the new observation – we see Bob in the hall, represented as

$$\alpha = HB$$

There are now three possibilities

1. We know that nobody has left the room.
   Conclusion – Alice is in the room. (Additional knowledge – it is impossible to be in two different places at once i.e. $HB \Leftrightarrow \neg RB$)

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2. We suppose that somebody might leave the room but we are not sure.
   Conclusion - There is Alice in the room or nobody.
3. We see Bob leaving the room.
   Conclusion - nobody is in the room. (Additional knowledge – we know the action and its precondition RB, i.e. to leave the room you must be in it before, thus, with the previous knowledge, we get the above conclusion). Go Return

Example 4

Consider the following schema:

$KB = A \wedge (A \Rightarrow B)$
$\alpha = \neg A$

$KB \wedge \alpha$ is inconsistent then we must delete something from KB to receive consistent KB'. In this case it is simple - deleting A we get $KB' \equiv \neg A \wedge (A \Rightarrow B)$.

Assume now that $\alpha = \neg B$ and KB is as before.

$KB \wedge \alpha$ is inconsistent too and we must delete something from KB. But now, it is not clear what should be deleted. The possible candidates are:

1. A
2. $A \Rightarrow B$
3. $A \wedge (A \Rightarrow B)$

The above examples show that depending on the context we need to consider three types of knowledge base modification

1. Belief revision
2. Belief update
3. Reasoning about action and change

Arising problems

- Frame problem (inertia, persistence)
  As little as possible should be changed (belief revision).
  The only things that should be changed are those which are known to be changed, the rest should remain unchanged (dynamical situations).
- Ramification problem
  Knowledge about the world under consideration – domain constraint axioms or integrity constraints.
  They have to be satisfied in all states of the world. It may lead to indirect effects and may collide with inertia.

Remark 1

It can not always be realized in a pure logical way. It often requires additional semantic information (a light example).

Example 5

Consider the following axiom.

$$l \Leftrightarrow (sw1 \Leftrightarrow sw2)$$

where $l, sw1, sw2$ denotes *light, switch1, switch2* respectively.

In the initial situation both switches are on (true) thus, by the axiom, the light is on.

We now make the switch1 off (false). The intended conclusion is that the light is off. But the resulting situation has two models

$$\{\neg l, \neg sw1, sw2\} \text{ and } \{l, \neg sw1, \neg sw2\}$$

The second one is unintended but we cannot eliminate it in a purely logical way.

Representation methods of Integrity Constraints

- Inertial and Non-inertial atoms

  Besides IC, two disjoint sets of atoms are defined. One includes atoms which cannot be changed implicitely by an action and the other the atoms which can.

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- Influence Relation

  It is binary relation between atoms. $R(a, b)$ denotes that if a is change by performing an action then b may change its value. Influence relation is transitive.

- Causality Rules

  IC are represented as *causal rules*. These are expressions of the form $\alpha \gg \beta$ and have the following intuitive interpretation:

  (1) The formula $\alpha \Rightarrow \beta$ holds in both the initial and the updated knowledge base.

  (2) If $\neg\alpha$ held in the initial knowledge base and α holds in the updated knowledge base, then there is a cause for β to hold in the updated knowledge base.

- Qualification problem
  It is not always possible to specify all preconditions of an action, i.e. conditions of its executability (reasoning about action).
  The idea is to keep them as separate formulae. It allows to add new preconditions in a simple way.

General assumptions

Belief revision

- A new observation is more reliable than the old one.
- We want to lose as little information as possible (persistence).
- Domain constraint axioms should remain unchanged.

General assumptions

Belief Update

- Both the new observation and the old one are reliable.
- Incompatibility is caused by performing an action.
- The only things that should be changed are those which are known to be changed, the rest should remain unchanged.
- Domain constraint axioms should remain unchanged.

General assumptions

Reasoning about action and change

- Both the new observation and the old one are reliable.
- Specification (i.e. preconditions and effects) of an action is known.
- Preconditions of the action must be satisfied otherwise the action has no effect.
- The only things that should be changed are those which are known to be changed, the rest should remain unchanged.
- Domain constraint axioms should remain unchanged.