Failure Analysis for Domain Knowledge Acquisition in a Knowledge-Intensive CBR System

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ICCBR-07

Principles

- The CBR system produces $\texttt{Sol}(\texttt{tgt})$, a solution for the target problem $\texttt{tgt}$.
  Assumption: $\texttt{Sol}(\texttt{tgt})$ is consistent with the domain knowledge $\texttt{DK}$.
- Domain knowledge acquisition from failures and interaction with the expert.
- Failures of type 1: $(\texttt{tgt}, \texttt{Sol}(\texttt{tgt}))$ is inconsistent with the *expert* knowledge (though it is consistent with $\texttt{DK}$)
- Failures of type 2: $\texttt{Sol}(\texttt{tgt})$ is only a partial (under-specified) solution
- Interactions with the expert
  - Who points out incorrect knowledge $\texttt{Inc}$:
    $\texttt{DK} := \texttt{DK} \wedge \neg\texttt{Inc}$
  - Who can write an explanation in plain text
    (to be used for off-line domain knowledge acquisition)

FrakaS

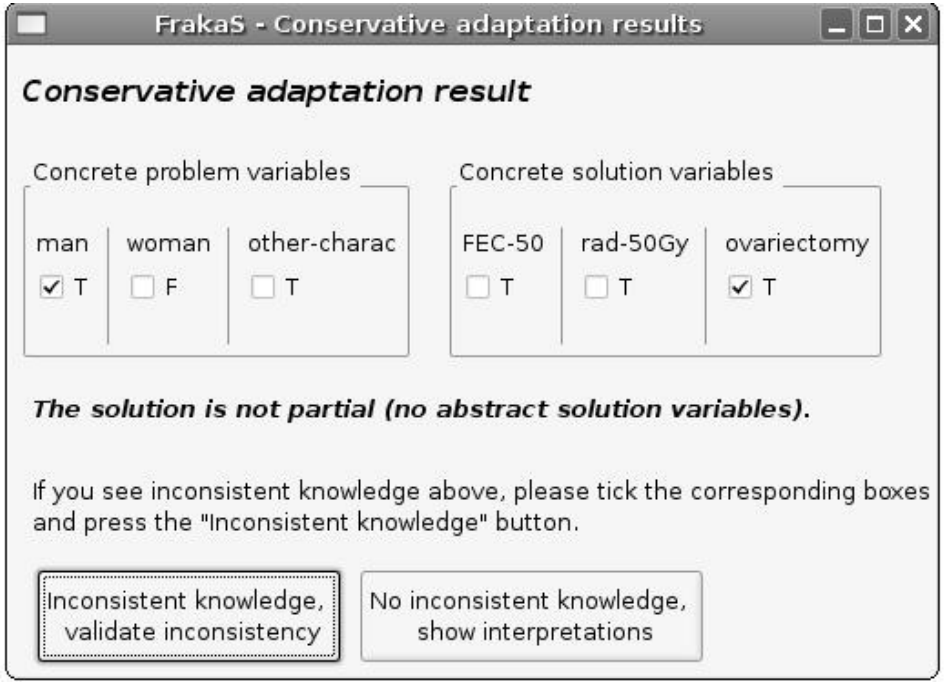
- FrakaS (FailuRe Analysis for domain Knowledge AcquiSition): a prototype implementing these principles in propositional logic
- Use of a CBR system where problems, solutions, and domain knowledge are expressed in propositional logic and that is based on $\circ_D$-conservative adaptation [Lieber, ICCBR-07]:
  - The source context is modified minimally to be consistent with the target context and the domain knowledge.
  - "Minimally": according to the Hamming distance between interpretations
- Some propositional variables are specified to be *abstract*.
  - A solution $\texttt{Sol(tgt)}$ is "partial" (cf. failures of type 2) if it cannot be expressed without abstract variables: for each formula f such that $\texttt{Sol(tgt)} \equiv_{\texttt{DK}} f$, f contains at least one abstract variable.
  - Abstract variables in the following: `chemotherapy`, `hormone-therapy`, `radiotherapy`, `anti-oestrogens`

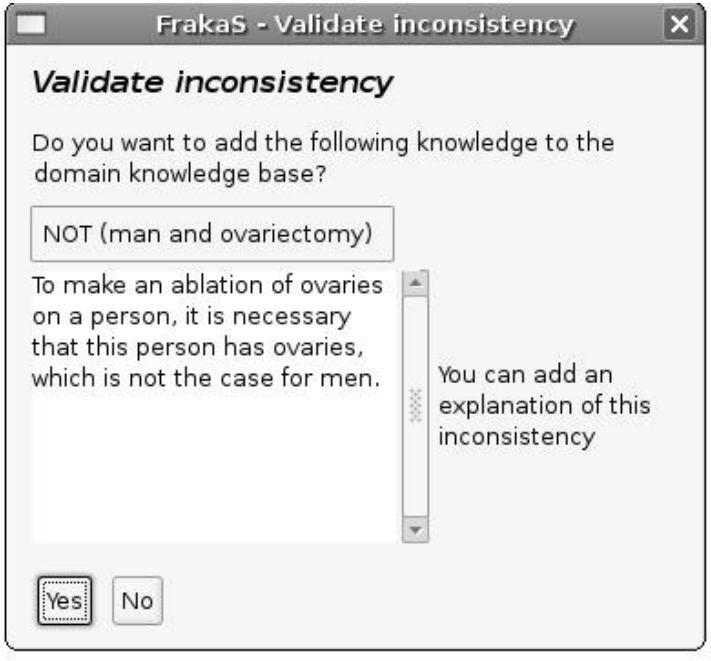
Example (1/6): 1st adaptation

$$
\begin{aligned}
\mathtt{DK}_0 = {} & (\neg \mathtt{woman} \vee \neg \mathtt{man}) \wedge \\
& (\mathtt{FEC\text{-}50} \Rightarrow \mathtt{chemotherapy}) \wedge \\
& (\mathtt{Rad\text{-}50Gy} \Rightarrow \mathtt{radiotherapy}) \wedge \\
& (\mathtt{ovary\text{-}ablation} \Rightarrow \mathtt{anti\text{-}oestrogens}) \wedge \\
& (\mathtt{tamoxifen} \Rightarrow \mathtt{anti\text{-}oestrogens}) \wedge \\
& (\mathtt{anti\text{-}aromatases} \Rightarrow \mathtt{anti\text{-}oestrogens}) \wedge \\
& (\mathtt{anti\text{-}oestrogens} \Rightarrow \mathtt{hormone\text{-}therapy}) \\
\mathtt{tgt} = {} & \mathtt{man} \wedge \mathtt{other\text{-}charac} \\
\mathtt{srce} = {} & \mathtt{woman} \wedge \mathtt{other\text{-}charac} \\
\mathtt{Sol(srce)} = {} & \mathtt{FEC\text{-}50} \wedge \mathtt{Rad\text{-}50Gy} \wedge \mathtt{ovary\text{-}ablation}
\end{aligned}
$$

$$
\mathtt{Sol(tgt)} \equiv_{\mathtt{DK}_0} \mathtt{Sol(srce)} = \mathtt{FEC\text{-}50} \wedge \mathtt{Rad\text{-}50Gy} \wedge \mathtt{ovary\text{-}ablation}
$$

Example (2/6): 1st interaction with the expert



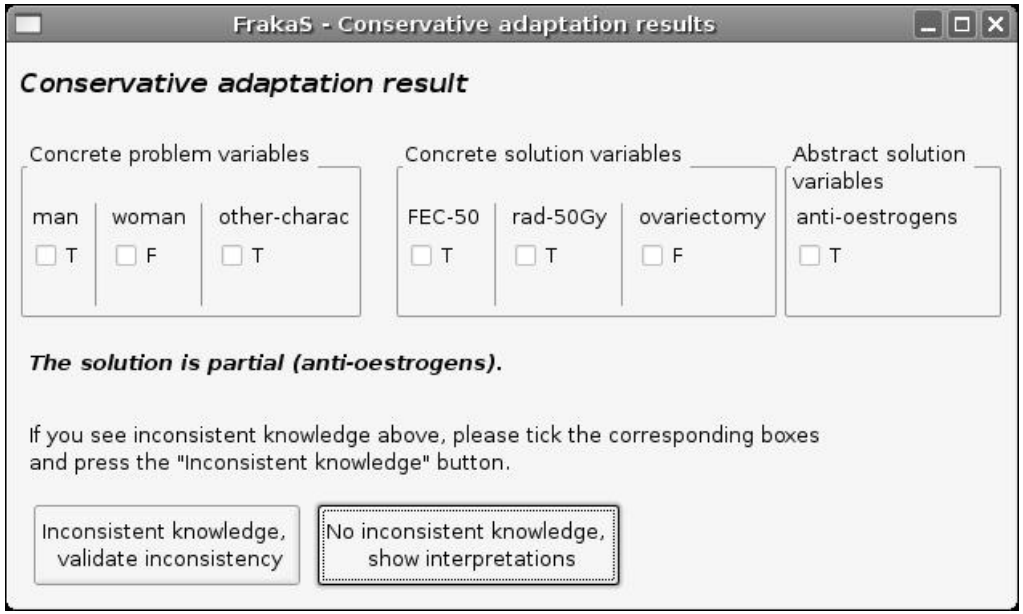


- DK is updated:

$$\begin{aligned} \mathtt{DK}_1 &= \mathtt{DK}_0 \wedge \neg(\mathtt{man} \wedge \mathtt{ovary\text{-}ablation}) \\ &\equiv \mathtt{DK}_0 \wedge (\mathtt{man} \Rightarrow \neg\mathtt{ovary\text{-}ablation}) \end{aligned}$$

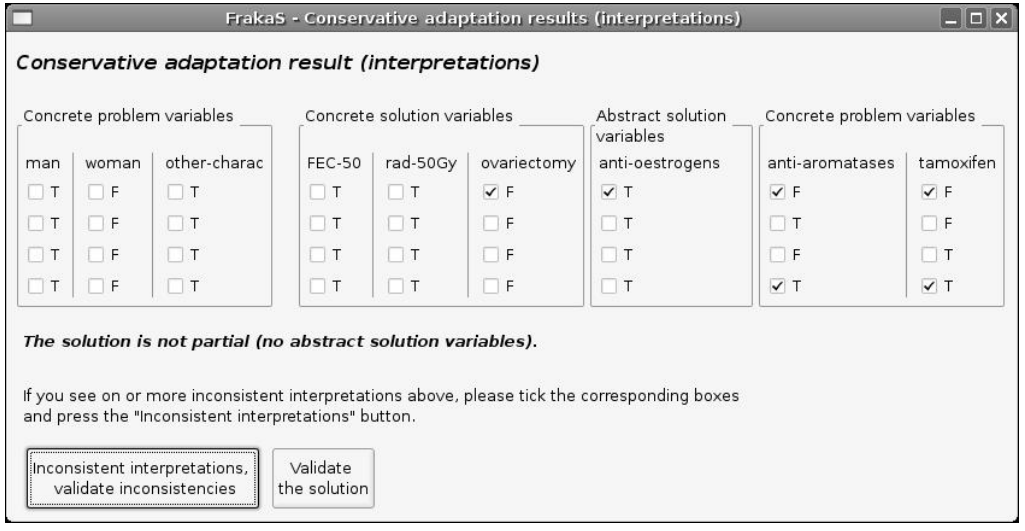
Example (3/6): 2nd adaptation and 2nd interaction

$$\texttt{Sol(tgt)} \equiv_{\texttt{DK}_1} \texttt{FEC-50} \wedge \texttt{Rad-50Gy} \wedge \neg\texttt{ovary-ablation} \wedge \texttt{anti-oestrogens}$$



- The expert points out no type 1 failure.
- But there is a type 2 failure: the solution is partial
  - → To deal with it, the interpretations are to be shown.

Example (4/6): 2nd interaction *(continued)*



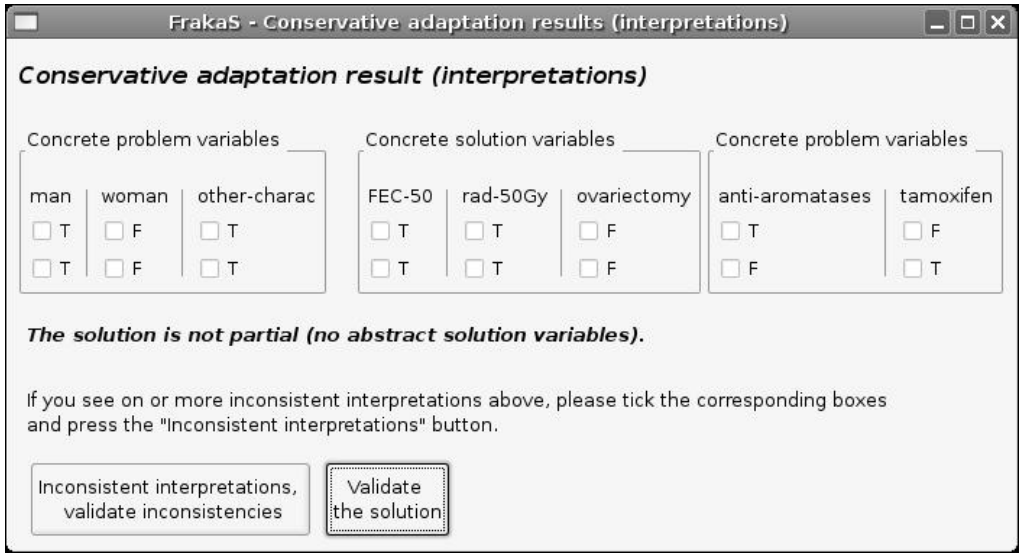
- The expert check the two interpretations that he/she rejects.
- DK is updated twice:

$$\mathtt{DK}_2 = \mathtt{DK}_1 \wedge \left(\mathtt{anti\text{-}oestrogens} \Rightarrow \left(\begin{array}{c} \mathtt{ovary\text{-}ablation} \vee \\ \mathtt{tamoxifen} \vee \\ \mathtt{anti\text{-}aromatases} \end{array} \right) \right)$$

$$\mathtt{DK}_3 = \mathtt{DK}_2 \wedge (\neg \mathtt{tamoxifen} \vee \neg \mathtt{anti\text{-}aromatases})$$

Example (5/6): 3^d adaptation and 3^d interaction

$$\texttt{Sol(tgt)} \equiv_{\texttt{DK}_3} \texttt{FEC-50} \wedge \texttt{Rad-50Gy} \wedge \neg\texttt{ovary-ablation} \wedge (\texttt{tamoxifen} \oplus \texttt{anti-aromatases})$$



- The expert validates this solution.

Example (6/6): Off-line domain knowledge acquisition

- The experts has given the following explanations:

text 1 To make an ablation of ovaries on a person, it is necessary that this person has ovaries, which is not the case for men.

text 2 The only therapies that are possible and permitted in my hospital for an anti-oestrogen treatment are the ovariectomy, the tamoxifen, and the anti-aromatases.

text 3 A given hormone therapy should not use at the same time tamoxifen and anti-aromatases.

- Through discussions between the computer scientist and the experts, this leads to:

$$\begin{aligned}\texttt{DK}_4 = \texttt{DK}_3 \wedge\ & (\texttt{man} \Rightarrow \neg\texttt{has-ovaries}) \wedge \\ & (\texttt{ovary-ablation} \Rightarrow \texttt{has-ovaries}) \wedge \\ & (\texttt{antecedent-ovariectomy} \Rightarrow \neg\texttt{has-ovaries}) \wedge \\ & \left(\texttt{anti-oestrogens} \Rightarrow \left(\begin{array}{c}\texttt{ovary-ablation} \vee \texttt{tamoxifen} \\ \vee\texttt{anti-aromatases}\end{array}\right)\right)\end{aligned}$$

Conclusion and Ongoing Work

- An approach to interactive domain knowledge acquisition from failures

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- Experiments: will be based on $\mathtt{DK}_{initial}$ and $\mathtt{DK}_{final}$
  - $\mathtt{DK}_{final}$ = "expert knowledge" (the goal)
  - Random generation of target problems
- From propositional logic to a description logic: FrakaS-DL
- Giving up the assumption
  "DK is consistent with the expert"
  - Replacing $\mathtt{DK}_{i+1} = \mathtt{DK}_i \wedge f$
  - By $\mathtt{DK}_{i+1} = \mathtt{DK}_i \circ f$
    ($\circ$ is a revision operator)