

Engineering and learning of adaptation knowledge in Case-Based Reasoning

Amélie Cordier, Béatrice Fuchs and Alain Mille

LIRIS UMR 5205. *CNRS/INSA de Lyon/Université Lyon 1/Université
Lyon2/Ecole Centrale de Lyon*
<http://liris.cnrs.fr>

EKAW - October 2006

Outline

- 1 Context
 - Problem
 - Knowledge engineering in CBR
- 2 Knowledge discovery
 - Adaptation
 - Dependency model
 - Learning strategies
- 3 Perspectives
 - Work in progress
 - Future work

Case-Based Reasoning (CBR)

Adaptation
knowledge discovery
in CBR

*Amélie Cordier,
Béatrice Fuchs and
Alain Mille*

Context

Problem
KE in CBR

Knowledge discovery

Adaptation
Dependency model
Learning strategies

Perspectives

Work in progress
Future work

- Case-Based Reasoning: problem solving approach
- Knowledge base: case base
- CBR cycle: elaborate, retrieve, reuse, revise and retain

Case-Based Reasoning: a solution to the knowledge acquisition bottleneck?

Case-Based Reasoning (CBR)

Adaptation
knowledge discovery
in CBR

*Amélie Cordier,
Béatrice Fuchs and
Alain Mille*

Context

Problem
KE in CBR

Knowledge discovery

Adaptation
Dependency model
Learning strategies

Perspectives

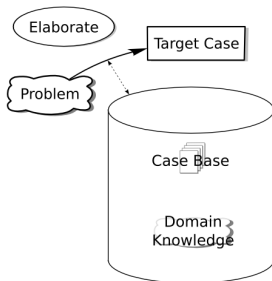
Work in progress
Future work

- Case-Based Reasoning: problem solving approach
- Knowledge base: case base
- CBR cycle: elaborate, retrieve, reuse, revise and retain

Case-Based Reasoning: a solution to the knowledge acquisition bottleneck?

- Main knowledge units: cases
- Additional knowledge units to reason on cases

Knowledge engineering in the CBR cycle



Elaborate: Domain knowledge. Describe a correct case.

Adaptation
knowledge discovery
in CBR

*Amélie Cordier,
Béatrice Fuchs and
Alain Mille*

Context

Problem
KE in CBR

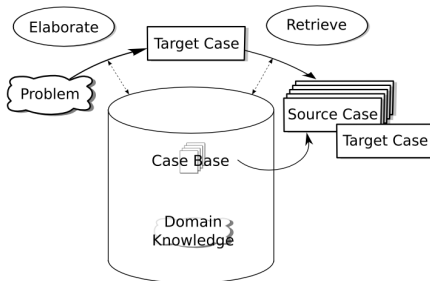
Knowledge discovery

Adaptation
Dependency model
Learning strategies

Perspectives

Work in progress
Future work

Knowledge engineering in the CBR cycle



Retrieve: Similarity knowledge. Preparation of adaptation.

Adaptation
knowledge discovery
in CBR

*Amélie Cordier,
Béatrice Fuchs and
Alain Mille*

Context

Problem
KE in CBR

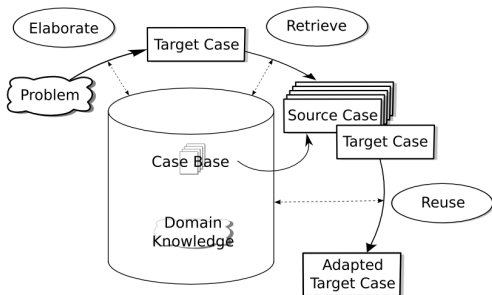
Knowledge discovery

Adaptation
Dependency model
Learning strategies

Perspectives

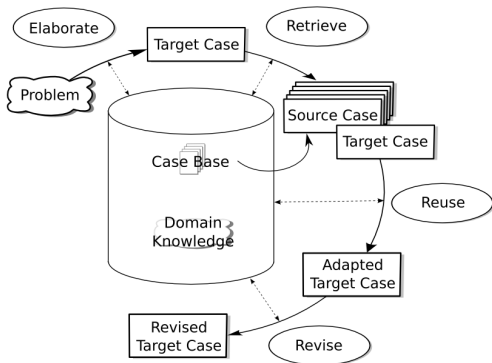
Work in progress
Future work

Knowledge engineering in the CBR cycle



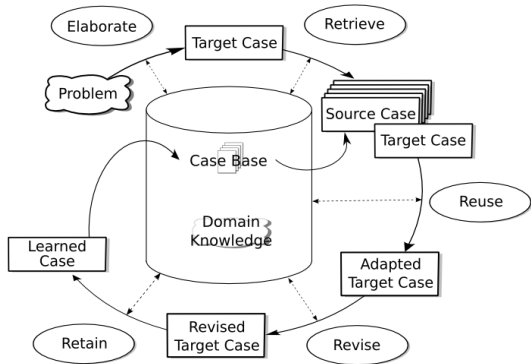
Reuse: Adaptation knowledge. Estimate a solution.

Knowledge engineering in the CBR cycle



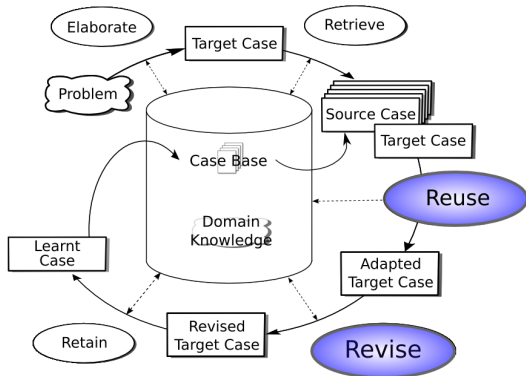
Revise: Interactions between the system and the user.

Knowledge engineering in the CBR cycle



Retain: New knowledge is added to the knowledge base.

Knowledge engineering in the CBR cycle



Steps of importance: reuse and revise

Knowledge units in CBR

Adaptation
knowledge discovery
in CBR

*Amélie Cordier,
Béatrice Fuchs and
Alain Mille*

Context

Problem
KE in CBR

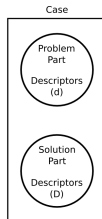
Knowledge discovery

Adaptation
Dependency model
Learning strategies

Perspectives

Work in progress
Future work

- Cases:
 - Problem solving experiences
 - Three main parts : problem description, solution description and reasoning process
- Other knowledge units:
 - Domain knowledge
 - Similarity knowledge
 - Adaptation knowledge



Relationship between similarity and adaptation

Adaptation
knowledge discovery
in CBR

*Amélie Cordier,
Béatrice Fuchs and
Alain Mille*

Context
Problem
KE in CBR

Knowledge discovery
Adaptation
Dependency model
Learning strategies

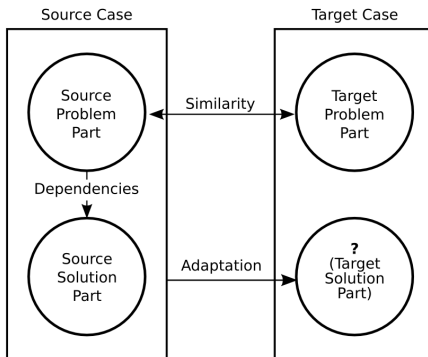
Perspectives
Work in progress
Future work

- Each step should prepare the next step
- Similar cases are cases that can be adapted using the same adaptation method
- Adaptability of a case must be taken into account during the retrieval process

⇒ *Formalise similarity and adaptation knowledge to facilitate their learning*

Adaptation?

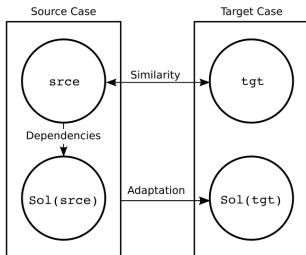
Adaptation by substitution [Fuchs, Lieber, Mille, Napoli - 2000]



Retrieval: $\text{target} \mapsto (\text{srce}, \text{Sol}(\text{srce}))$

Adaptation: $\text{srce}, \text{Sol}(\text{srce}), \text{tgt} \mapsto \text{Sol}(\text{tgt})$

The dependency model



- $srce: \{d_i^s\}_{i=1..n}$
- $Sol(srce): \{D_j^s\}_{j=1..N}$
- $tgt: \{d_i^t\}_{i=1..n}$
- $Sol(tgt): \{D_j^t\}_{j=1..N}$

The dependency model

Adaptation
knowledge discovery
in CBR

*Amélie Cordier,
Béatrice Fuchs and
Alain Mille*

Context

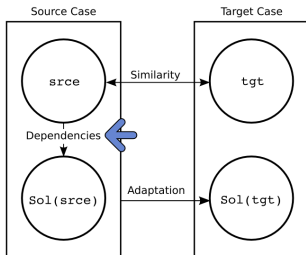
Problem
KE in CBR

Knowledge discovery

Adaptation
Dependency model
Learning strategies

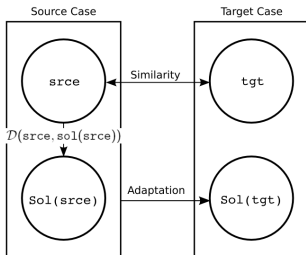
Perspectives

Work in progress
Future work



- $srce: \{d_i^s\}_{i=1..n}$
- $Sol(srce): \{D_j^s\}_{j=1..N}$
- $tgt: \{d_i^t\}_{i=1..n}$
- $Sol(tgt): \{D_j^t\}_{j=1..N}$

The dependency model



- $\text{srce}: \{d_i^s\}_{i=1..n}$
- $\text{Sol}(\text{srce}): \{D_j^s\}_{j=1..N}$
- $\text{tgt}: \{d_i^t\}_{i=1..n}$
- $\text{Sol}(\text{tgt}): \{D_j^t\}_{j=1..N}$

- $\mathcal{D}(\text{srce}, \text{sol}(\text{srce}))$ is a set of $(d_i, D_j, \mathcal{I}(D_j/d_i))$
- $\mathcal{I}(D_j/d_i)$ expresses the effect of a variation of d_i on D_j
- Thresholds are used to check the applicability of a dependency

Reasoning using the dependency model

Adaptation
knowledge discovery
in CBR

Amélie Cordier,
Béatrice Fuchs and
Alain Mille

Context
Problem
KE in CBR

Knowledge discovery
Adaptation
Dependency model
Learning strategies

Perspectives
Work in progress
Future work

- Elaborate:
 - Select a relevant dependency set
- Retrieve:
 - Find relevant descriptors according to the dependencies
 - Set the weights
 - Retrieve a case
- Adapt:
 - Apply influence functions

⇒ *Similarity and adaptation knowledge are linked in the dependencies*

Knowledge contained in a dependence

Adaptation
knowledge discovery
in CBR

*Amélie Cordier,
Béatrice Fuchs and
Alain Mille*

Context

Problem
KE in CBR

Knowledge discovery

Adaptation
Dependency model
Learning strategies

Perspectives

Work in progress
Future work

- **Influence functions:** numeric functions, cases, rules
- **Dependencies:** link between a problem descriptor and a solution descriptor
- **Dependency set:** set of dependencies used to solve problems belonging to the same class of problems

Learning targets

- Influence functions:
 - Applicability thresholds
 - Numeric functions parameters
 - New rules
- Dependencies:
 - Discovery of a dependency
 - Context of usability
- Problem classes:
 - Identification of a new problem class

Learning strategies

Adaptation

knowledge discovery
in CBR

*Amélie Cordier,
Béatrice Fuchs and
Alain Mille*

Context

Problem
KE in CBR

Knowledge discovery

Adaptation
Dependency model
Learning strategies

Perspectives

Work in progress
Future work

- 1 Exploiting differences between adapted solution and revised solution
- 2 Performing a retrieve step on the solutions
- 3 Replaying the reasoning process with the user

1. Exploiting differences between adapted and revised solution

Adaptation
knowledge discovery
in CBR

*Amélie Cordier,
Béatrice Fuchs and
Alain Mille*

Context

Problem
KE in CBR

Knowledge discovery

Adaptation
Dependency model
Learning strategies

Perspectives

Work in progress
Future work

- Main process:
 - Find differences between adapted solutions
 - Select dependencies used to compute descriptors values
 - Modify dependencies to take into account the corrections made by the expert user

- In order to:
 - Refine applicability thresholds
 - Modify influence function parameters
 - Discover new dependencies

2. Performing a retrieval step on the solutions

- Main process:
 - Start a retrieval process on the solution part of the cases
 - Compare the reasoning processes of the retrieved case and the target case
 - Exploit learning techniques and user interactions to discover new knowledge

- In order to:
 - Refine applicability thresholds
 - Modify influence function parameters
 - Discover new dependencies

3. Replaying the reasoning process

- Replay the whole reasoning process allowing more interactions between the system and the expert user:
 - Choose the appropriate dependency set
 - Modify the thresholds of dependencies
 - Change an influence function parameter
- Validate new knowledge with the user
- Store new knowledge in the system for future use

Learning process overview

Adaptation
knowledge discovery
in CBR

*Amélie Cordier,
Béatrice Fuchs and
Alain Mille*

Context

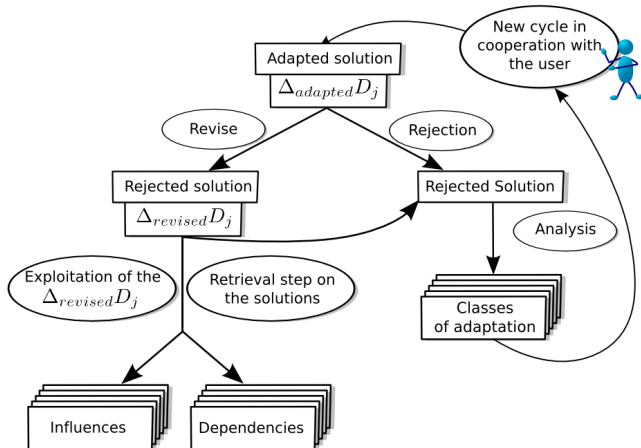
Problem
KE in CBR

Knowledge discovery

Adaptation
Dependency model
Learning strategies

Perspectives

Work in progress
Future work



Work in progress...

JColibri:

- **GAIA** - Group for Artificial Intelligence Applications, Madrid
- Java prototyping framework for CBR applications
- Tasks/methods approach, problem solving methods library
- Extensible



Implementation of a prototype in JColibri:

- Dependency model
- JColibri methods using this model
- Experimental domain: the travel agency problem

Future work

Hypothesis:

- Dependencies: a way to express similarity and adaptation knowledge
- Expert user: a main actor in adaptation knowledge acquisition

We want to:

- Experiment the three strategies
- Check the validity of the dependency model when features are symbolics
- Improve the interactions between the system and the user by improving the knowledge presentation

Adaptation
knowledge discovery
in CBR

*Amélie Cordier,
Béatrice Fuchs and
Alain Mille*

Context

Problem
KE in CBR

Knowledge discovery

Adaptation
Dependency model
Learning strategies

Perspectives

Work in progress
Future work

Thank you!

Bibliographie

Adaptation
knowledge discovery
in CBR

Amélie Cordier,
Béatrice Fuchs and
Alain Mille

Context

Problem
KE in CBR

Knowledge discovery

Adaptation
Dependency model
Learning strategies

Perspectives

Work in progress
Future work

- Fuchs, B., J. Lieber, A. Mille, et A. Napoli (2000). An Algorithm for Adaptation in Case-Based Reasoning. In W. Horn (Ed.), 14th European Conference on Artificial Intelligence - *ECAI'2000*, Berlin, Germany.
- Hanney, K., et M. T. Keane (1996). Learning Adaptation Rules from a Case-Base. In *Proceedings of the Third European Workshop on Advances in case-Based Reasoning*.
- Leake, D. B. (1995). Becoming an Expert Case-Based Reasoner : Learning to Adapt Prior Cases. In *Eighth Annual Florida Artificial Intelligence Research Symposium*, 112-116.
- Leake, D. B., A. Kinley, et D. Wilson (1997). Case-Based Similarity Assessment : Estimating Adaptability from Experience. In *Fourteenth National Conference on Artificial Intelligence*, Menlo Park, CA.
- Smyth, B. et M. T. Keane (1995). Remembering to forget : A competence-preserving case deletion policy for case-based reasoning systems. In *IJCAI*.
- Smyth, B. et M. T. Keane (1998). Adaptation-guided retrieval : Questioning the similarity assumption in reasoning. *Artificial Intelligence 102(2)*, 249-293.