Case-Based Reasoning

10/23/02
Why CBR?

- Problem: Most of the time the trouble in Building Expert Systems comes from trying to fit experience into rules.
The CBR Solution

Experience → Experience
CBR: A methodology of solving new problems by adapting the solutions of previous similar problems
What is Case-Based Reasoning?

- A kind of ‘table look-up’
- CBR system looks up in case base (indexed store of cases) past cases that bear on current problem
- Indexing and case representation facilitate retrieving relevant cases and comparing them with current problem
- CBR system applies information in retrieved cases to analyzing or solving problem
Case-Based Reasoning

The use of previous experience in new situations

“I have but one lamp by which my feet are guided, and that is the lamp of experience. I know no way of judging the future but by the past.” Patrick Henry (Speech in Virginia Convention, Richmond. March 23, 1775)
Processing takes place in 3 stages

- Current Situation
- Retrieve similar cases from the library
- Adapt
Case-Based Reasoning

“.... transferring knowledge from past problem solving episodes to new problems that share significant aspects with corresponding past experience and using the transferred knowledge to construct solutions to new problems.” (Carbonell, 1986)
Introductory Examples of CBR

- **Classification:** “The patient’s ear problems are like this prototypical case of otitis media”
- **Compiling solutions:** “Patient N’s heart symptoms can be explained in the same way as previous patient D’s”
- **Assessing values:** My house is like the one that sold down the street for $250,000 but has a better view”
- **Justifying with precedents:** “This Missouri case should be decided just like Roe v. Wade where the court held that a state’s limitations on abortion are illegal”
- **Evaluating options:** “If we attack Cuban/Russian missile installations, it would be just like Pearl Harbor”
Building An Application

• Steps
  – Case Representation
  – Case Input
  – Case Indexing
  – Case Retrieval
  – Evaluation and Comparison
  – Case Adaptation
Case Representation

- This is the first step in building an application
- Examples are made up of key features

![Diagram showing key features of a car: Year, Model, Make, Options, Condition, Mileage]
Case Indexing

- Indexing gives the system knowledge on how to make matches
- What features are important and how much they contribute to the match
  - LoKI (Dattani and Bramer 1995) implements mathematical models to derive an appropriate function:
    - $Y = f(X_1, X_2, X_7)$ using Multivariate techniques
Sample CBR Applications

- Machine Tool Fault Diagnosis
- Computer Network Diagnosis
- Credit Analysis
- Geological Deposit Prediction
- Battle Planning
- Bank Telex Classification
- Natural Language Understanding
Other CBR Applications

• Network Management
• Legal Reasoning
• Claims Settlement
• Medical Diagnosis
• Weather Prediction
• Fraud Detection
• Planning and Scheduling
Professor Edwina Rissland (Harvard Law School) speaking at AAAI-92 on 'Recent Progress in AI and Legal Reasoning'
### Reasoning with Precedent Cases

#### The Term Papers Example

<table>
<thead>
<tr>
<th>Days Late</th>
<th>Medical Certificate?</th>
<th>Accepted?</th>
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<tbody>
<tr>
<td>7</td>
<td>NO</td>
<td>NO</td>
</tr>
<tr>
<td>5</td>
<td>YES</td>
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</tr>
<tr>
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<td>NO</td>
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<td>6</td>
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<tr>
<td>6</td>
<td>YES</td>
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<tr>
<td>4</td>
<td>NO</td>
<td>???</td>
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Contents of Cases

• Minimum Representation
  Problem description
  Problem solution

• Extensions
  Context (justification etc.)
  Links to other cases
  Failures encountered
## Some Case-Based Systems

<table>
<thead>
<tr>
<th>Name</th>
<th>Application</th>
<th>Year</th>
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<tbody>
<tr>
<td>CYRUS</td>
<td>Episodic Memory</td>
<td>1980</td>
</tr>
<tr>
<td>MEDIATOR</td>
<td>Dispute Resolution</td>
<td>1985</td>
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<tr>
<td>PLEXUS</td>
<td>Adaptive Planning</td>
<td>1986</td>
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<td>JUDGE</td>
<td>Criminal Sentencing</td>
<td>1986</td>
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<tr>
<td>SWALE</td>
<td>Case-Based Explanation</td>
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<td>CHEF</td>
<td>Chinese Cooking</td>
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<td>MBRTalk</td>
<td>Pronunciation of Words</td>
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<td>JULIA</td>
<td>Catering</td>
<td>1987</td>
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<tr>
<td>HYPO</td>
<td>Patent Law</td>
<td>1987</td>
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<td>COACH</td>
<td>Football Coach</td>
<td>1988</td>
</tr>
<tr>
<td>CASEY</td>
<td>Heart Failure Diagnosis</td>
<td>1988</td>
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<td>JOHNNY</td>
<td>Reading</td>
<td>1988</td>
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<td>REFINER</td>
<td>Knowledge Refinement</td>
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</tr>
<tr>
<td>Name</td>
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<td>Year</td>
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<tr>
<td>---------------</td>
<td>-------------------------</td>
<td>------</td>
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<td>PROTOS</td>
<td>Knowledge Acquisition</td>
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<td>Planning</td>
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<td>PATDEX</td>
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When should CBR be used?

Where ....

- A large volume of historical data already exists
- Experts talk about their domain by giving examples
- Experience is as valuable as textbook knowledge
- Problems are not fully understood (weak models, little domain knowledge available)
- There are a lot of exceptions to rules
- There is a need to build a corporate memory and transfer expertise among personnel
CBR versus Rule-Based Systems

- CBR offers a cost-effective solution to the ‘knowledge acquisition bottleneck’ problem
- CBR systems can learn from experience and so can be self-maintaining
- Rule-based systems are better when it is hard to gather case data
A Sample Example

- Technical Diagnosis of Car Faults
  - Symptoms are observed (e.g., engine does not start) and values are measured (e.g., battery voltage = 6.3V)
  - Goal: Find the cause for the failure (e.g., battery empty) and a repair strategy (e.g., charge battery)

- Case-based Diagnosis:
  - A case describes a diagnostic situation and contains:
    - Description of the symptoms
    - Description of the failure and cause
    - Description of a repair strategy
  - Store a collection of cases in a case base
  - Find case similar to current problem & reuse repair strategy
### Existing Cases

**Case 1**
- **Problem (Symptoms)**
  - Problem: Front light doesn’t work
  - Car: VW Golf II, 1.6 L
  - Year: 1993
  - Battery voltage: 13.6 V
  - State of lights: OK
  - State of light switch: OK
- **Solution**
  - Diagnosis: Front light fuse defect
  - Repair: Replace front light fuse

**Case 2**
- **Problem (Symptoms)**
  - Problem: Front light doesn’t work
  - Car: Audi A6
  - Year: 1995
  - Battery voltage: 12.9 V
  - State of lights: surface damaged
  - State of light switch: OK
- **Solution**
  - Diagnosis: Bulb defect
  - Repair: Replace front light
Case Representation

• Case-based reasoner depends heavily on the structure and content of its collection of cases.

• Since a problem is solved by recalling a previous experience suitable for solving the current problem, the case search and matching process has to be effective and reasonably time efficient.
Case Representation

- Flat feature-value list
- Object Oriented representation
- Graph representation

- The choice of representation is
  - Dependent on requirements of domain and task
  - Structure of already available case data
Problem to be solved

Problem (Symptom):
- *Problem:* Break light doesn’t work
- *Car:* Audi 80
- *Year:* 1989
- *Battery voltage:* 12.6 V
- *State of light:* OK

Figure Credit: R. Bergmann, University of Kaiserslautern
Case Retrieval

- Retrieval starts with a (partial) problem description, and ends when a best matching previous case has been found.
Similarity Measurement

• Purpose: To select the most relevant case
• Basic Assumption: Similar problems have similar solutions
• Similarity value between 0 and 1 are assigned for feature value pairs
• E.g.: Feature: Problem

Front Light does not work  .8
Break Light does not work

Front Light does not work  .4
Engine doesn’t start
Similarity Measurement

- Feature: Battery Voltage

\[
\begin{align*}
12.6 &- 13.6 & 12.6 &- 6.7 \\
.9 & & .1
\end{align*}
\]

- Different features have different importance
- Two kinds of Similarity Measures
  - Local Similarity – similarity on feature level
  - Global Similarity - similarity on case or object level
Similarity Computation for case 1

Problem (Symptom)
- Prob.: Break light doesn’t work
- Car: Audi 80
- Year: 1989
- Battery voltage: 12.6 V
- State of lights: OK

Problem (Symptoms)
- Prob.: Front light doesn’t work
- Car: VW Golf II, 1.6 L
- Year: 1993
- Battery voltage: 13.6 V
- State of lights: OK
- State of light switch: OK

Solution
- Diagnosis: Front light fuse defect
- Repair: Replace front light fuse

Very important feature: weight = 6
Less important feature: weight = 1

Similarity Computation by Weighted Average

\[ similarity(new, case 1) = \frac{1}{20} \times [ 6 \times 0.8 + 1 \times 0.4 + 1 \times 0.6 + 6 \times 0.9 + 6 \times 1.0 ] = 0.86 \]
Similarity Computation for case 2

Problem (Symptom)
- Prob.: Break light doesn’t work
- Car: Audi 80
- Year: 1989
- Battery voltage: 12.6 V
- State of lights: OK

Problem (Symptoms)
- Prob.: Front light doesn’t work
- Car: Audi A6
- Year: 1995
- Battery voltage: 12.9 V
- State of lights: surface damaged
- State of light switch: OK

Solution
- Diagnosis: Bulb defect
- Repair: Replace front light

Similarity Computation by Weighted Average

\[ similarity(new, case\ 2) = \frac{1}{20} \times [6 \times 0.8 + 1 \times 0.8 + 1 \times 0.4 + 6 \times 0.95 + 6 \times 0] = 0.585 \]
CBR on the Web
Welcome to CBR-Web

This is the Case-Based Reasoning homepage at the University of Kaiserslautern. It provides up-to-date information on CBR, relevant to both research and commercial topics.

You are currently not registered. If you plan to visit this page occasionally, you should consider to register.

Technical Notes
You can change settings to adapt the look of the CBR-Web to your preferences.

Most info pages have this pin icon at the bottom. If you click it, the whole page will be reloaded without your registration id or configuration settings. You can forward the address of this reloaded page to other people without showing them your settings. The address will point directly to
Quick Search...

Refine Search

Associated Environment

Associated Symptoms

Search Summary

2 Solutions to consider.
These are possible solutions to your problem. Click a solution for complete details.

1. AirConnect - Microsoft Windows XP - Working Configurations

2. AirConnect - How connect to a Wireless Hub that has Short Preamble Enabled
Analog devices: sales support

Finding the OP Amp that's right for you.

Parameter Search - Op Amps

Enter your performance requirements for all relevant parameters. Type the word "best" for any parameters you wish to optimize while still meeting your other requirements. For further information about search functions click HELP at any time.

DYNAMIC INPUT OUTPUT SUPPLY OTHER

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<th>Value 2</th>
<th>Value 3</th>
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Last Minute Flights and Travel

http://www.bfr-reisen.com/

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