Case-Based Reasoning is ...

- A methodology to model human reasoning and thinking
- A methodology for building intelligent computer systems

- **CBR in a nutshell:**
  - store previous experience (cases) in memory
  - to solve new problems:
    - retrieve similar experience about similar situations from the memory
    - reuse the experience in the context of the new situation: complete or partial reuse, or adapt according to differences
    - store new experience in memory (learning)

A Simple Example (Overview)

Technical Diagnosis of Car Faults

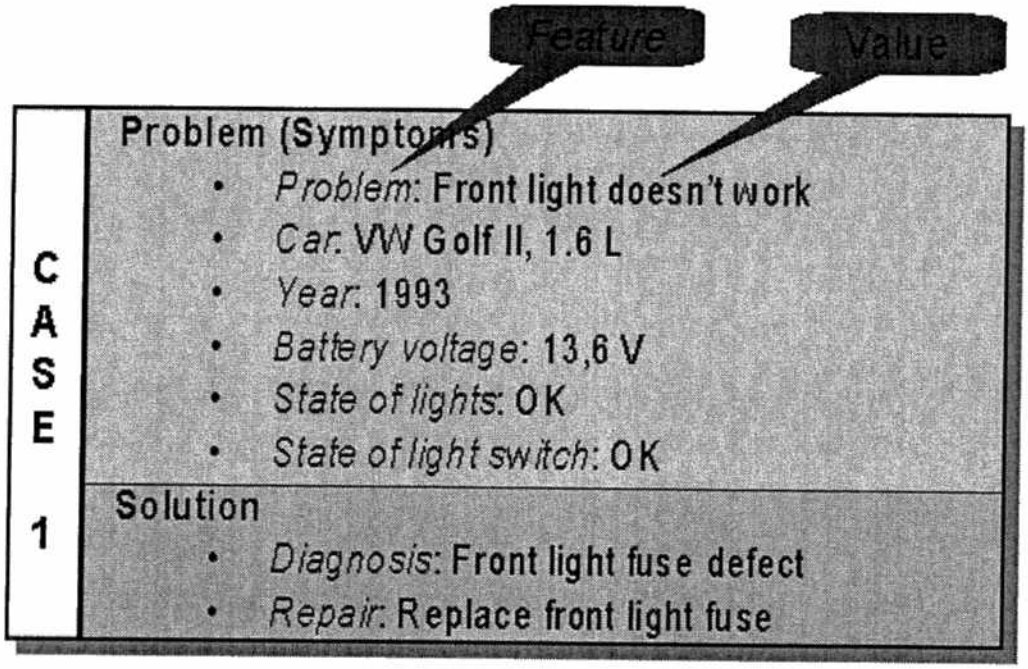
- Symptoms are observed (e.g. engine doesn't start) and values are measured (e.g. battery voltage = 6.3V)
- Goal: Find the cause for the failure (e.g. battery empty) and a repair strategy (e.g. charge battery)

Case-Based Diagnosis:

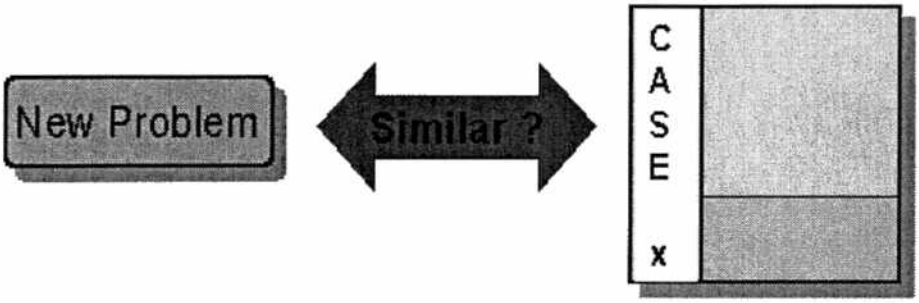
- A case describes a diagnostic situation and contains:
  - description of the symptoms
  - description of the failure and the cause
  - description of a repair strategy
- Store a collection of cases in a case base
- Find case similar to current problem and reuse repair strategy

A Simple Example: What's a Case ?

- A case describes one particular diagnostic situation
- A case records several features and their specific values occurred in that situation
- A case is not a rule !!



Compare the New Problem with Each Case and Select the Most Similar Case



- When are two cases similar?
- How to rank the cases according to their similarity?
- **Similarity is the most important concept in CBR !!**
- We can assess similarity based on the similarity of each feature
- Similarity of each feature depends on the feature **value**.
- BUT: Importance of different features may be different

A Case Base with Two Cases

- Each case describes one particular situation
- All cases are independent from each other

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)

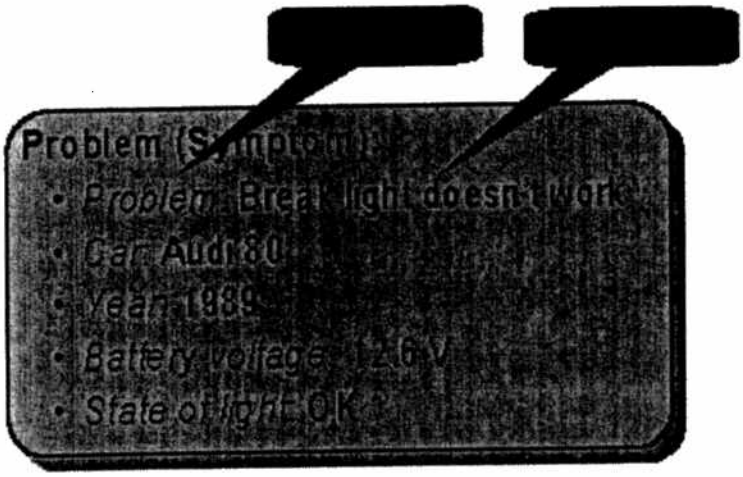
- Problem: Front light doesn't work
- Car: Audi A6
- Year: 1995
- Battery voltage : 12,9 V
- State of lights: surface damaged
- State of light switch: OK

Solution

- Diagnosis: Bulb defect
- Repair: Replace front light

Solving a New Diagnostic Problem

- A new problem must be solved
- We make several observations in the current situation
- Observations define a new problem
- Not all feature values must be known
- Note: The new problem is a case without solution part



Similarity Computation

- Assignment of similarities for features values.

- Express degree of similarity by a real number between 0 and 1

Examples:

  - Feature: *Problem*

    Front light doesn't work ←0.8→ Break light doesn't work

    Front light doesn't work ←0.4→ Engine doesn't start

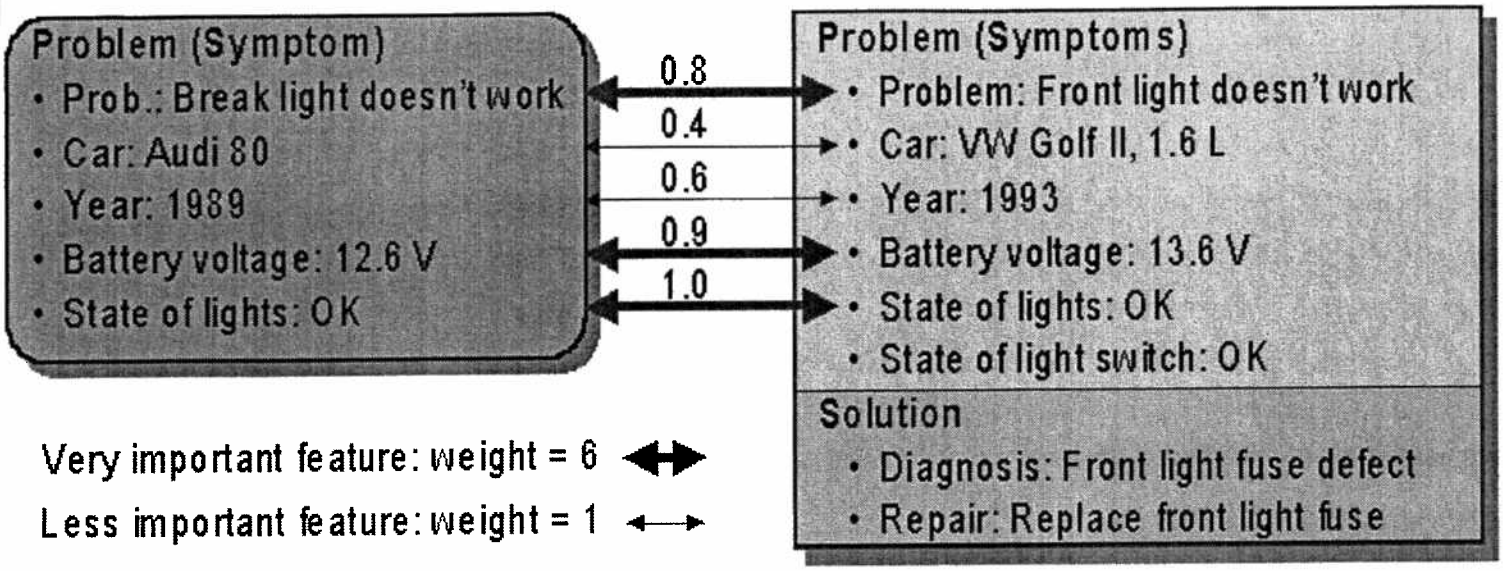
  - Feature: *Battery voltage* (similarity depends on the difference)

    12.6 V ←0.9→ 13.6 V

    12.6 V ←0.1→ 6.7 V

- Different features have different importance (weights) !
  - High importance: Problem, Battery voltage, State of light, ...
  - Low importance: Car, Year, ...

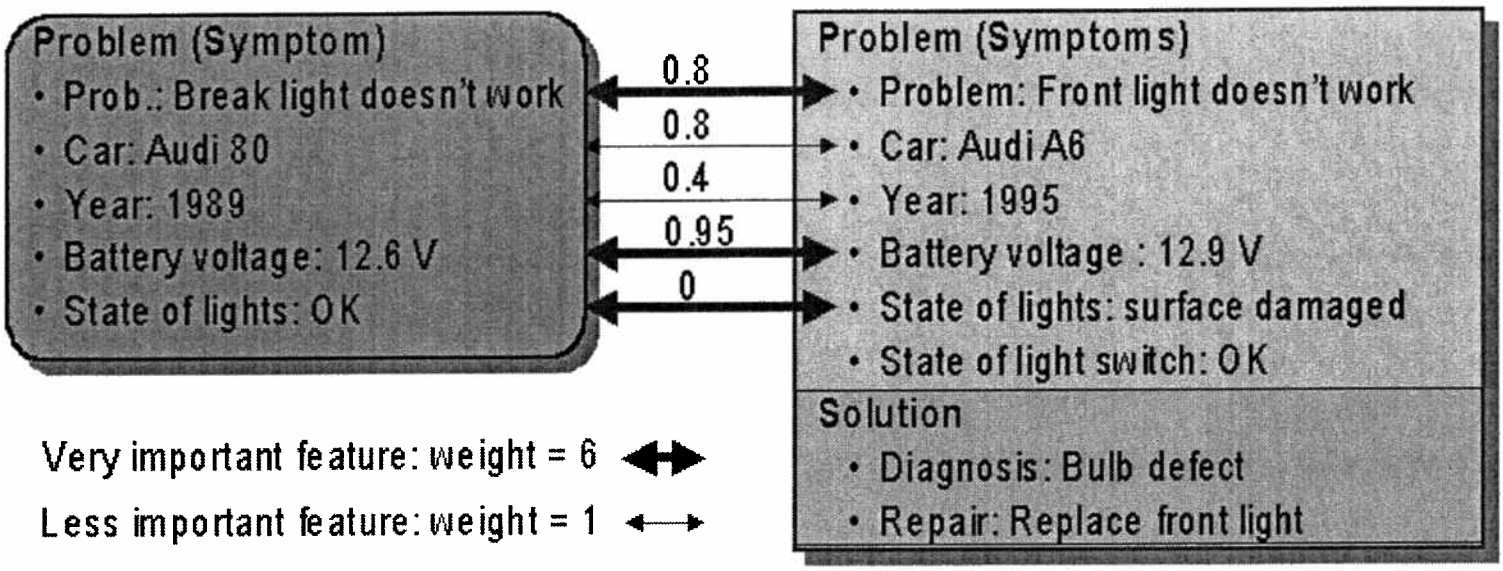
Compare New Problem and Case 1



Similarity Computation by Weighted Average

similarity(new,case 1) = 1/20 * [6*0.8 + 1*0.4 + 1*0.6 + 6*0.9 + 6* 1.0] = **0.86**

Compare New Problem and Case 2

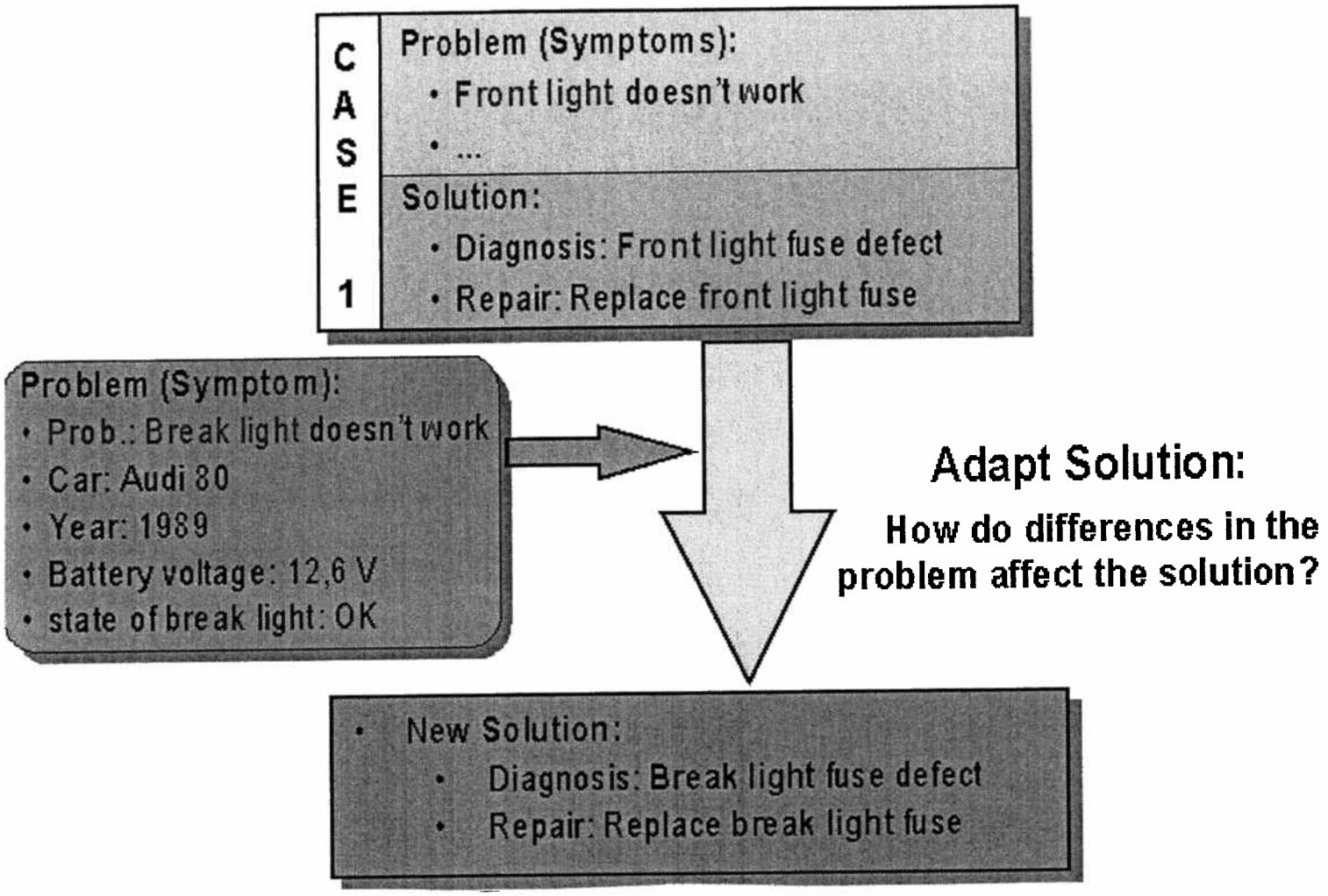


Similarity Computation by Weighted Average

similarity(new,case 2) = 1/20 * [6*0.8 + 1*0.8 + 1*0.4 + 6*0.95 + 6*0] = **0.585**

Case 1 is more similar: due to feature "State of lights"

Reuse the Solution of Case 1



Store the New Experience

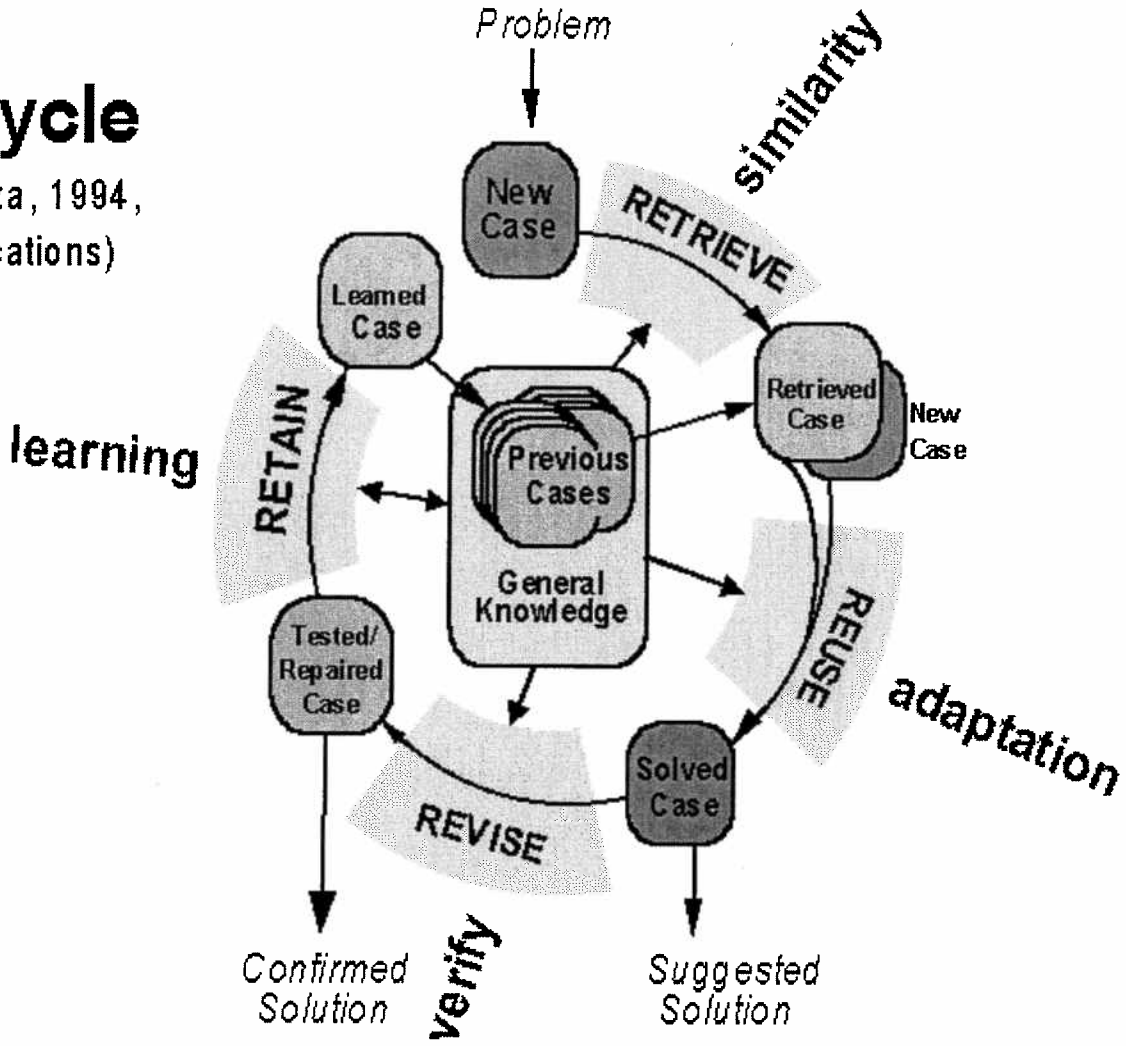
If diagnosis is correct:

store new case in the memory.

CASE 3	Problem (Symptoms): • Problem: Break light doesn't work • Car: Audi 80 • Year: 1989 • Battery voltage: 12.6 V • State of break lights: OK • light switch clicking: OK
	Solution: • Diagnosis: break light fuse defect • Repair: replace break light fuse

CBR Cycle

(Aamodt & Plaza, 1994, AI Communications)



Summary

- CBR is a technique for solving problems based on experience
- CBR problem solving involves four phases:

  Retrieve, Reuse, Revise, Retain
- CBR systems store knowledge in four containers:

  Vocabulary , Case Base , Similarity Assessment, Solution Adaptation

Retain: Learning from Problem Solving

- **What can be learned:**
  - New experience (new case)
  - Improved similarity assessment, importance of features
  - Organization/indexing of the case base to improve efficiency
  - Knowledge for solution adaptation
  - Forgetting cases, e.g., for efficiency or because out-of-date
- **Methods**
  - Storing cases in the case base
  - Deleting cases from the case base
  - Explanation-based learning
  - Induction, e.g. of decision trees
  - Neural net style learning

Less Effort Required for Maintenance

What is the impact of changes of the environment ?

- **Rule bases or models are difficult to maintain**
  - Many dependencies between rules
  - Rules of KBS often difficult to understand for non AI experts
  - Effects of changes of the rule base are hard to predict
  - Maintenance by the domain expert impossible !!
- **Case bases are easier to maintain**
  - Cases are independent from each other
  - Domain experts and novices understand cases quite easy
  - Maintenance of the CBR system (partially) by adding/deleting cases
  - However, changes in the vocabulary container require (little) more effort