

Knowledge-Based Systems For Development

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Outline

- Discussion of the research at *Schlumberger Cambridge Research* and *The World Bank*
- Knowledge, Decisions, and Policies
- Knowledge Representation
- A Case-based Approach
- Summary

What does the World Bank do?



- ❑ Invests in Economic and Social Development Projects to reduce poverty and improve living standards.
- ❑ Offers advice and an array of customized resources to developing countries.

The Role of Knowledge

The ability to create, access, use knowledge is a fundamental determinant of global competitiveness.

Main Issues



How to represent and access information?

How to share and transfer knowledge?

Information to Represent

In India in the 1950s, milk production could not keep pace with growing demand. Some milk vendors watered down the milk. Because there were many vendors, and brand names were not clearly established, vendors who did not dilute their milk could not command a premium and were squeezed out of the market. The result was an overall drop in milk quality. Enter the National Dairy Development Board that encouraged creation of dairy cooperatives ...

Decisions to Make

Policy Examples:

- How much to fund for primary education?
- Should the government intervene in vaccination of the public?

Oilfield Examples:

- Should we drill another producer well?
- Is it worth fixing the casing leak in well #A5?

Knowledge Sharing

- Lessons Learned and Best Practices
- Can best practices be replicated?
- How general is a best practice?
- Contrary to popular wisdom, there are times when it pays to reinvent the wheel!
- Local adaptation of a best practice amounts to reinventing the best practice in the new context.

Knowledge & Learning

- Two paradigms of learning: direct (passive) and indirect (active).
- In the direct method the teacher transmits knowledge to the passive student.
- In the indirect method, the student takes the active role of discovering knowledge.

Active Learning

- Socratic teacher: a midwife to student's learning experience
- Transformation of the student into an active constructor and appropriator of knowledge.
- Learning occurs in activity.
- The goal is to create systems that promote interaction between people, machines and the environment.

Decision-Theoretic Systems

- Probabilities are used to describe what an agent should believe on the basis of evidence.
- Utility theory describes what an agent wants.
- Decision theory puts the two together to describe what an agent should do.

Utility

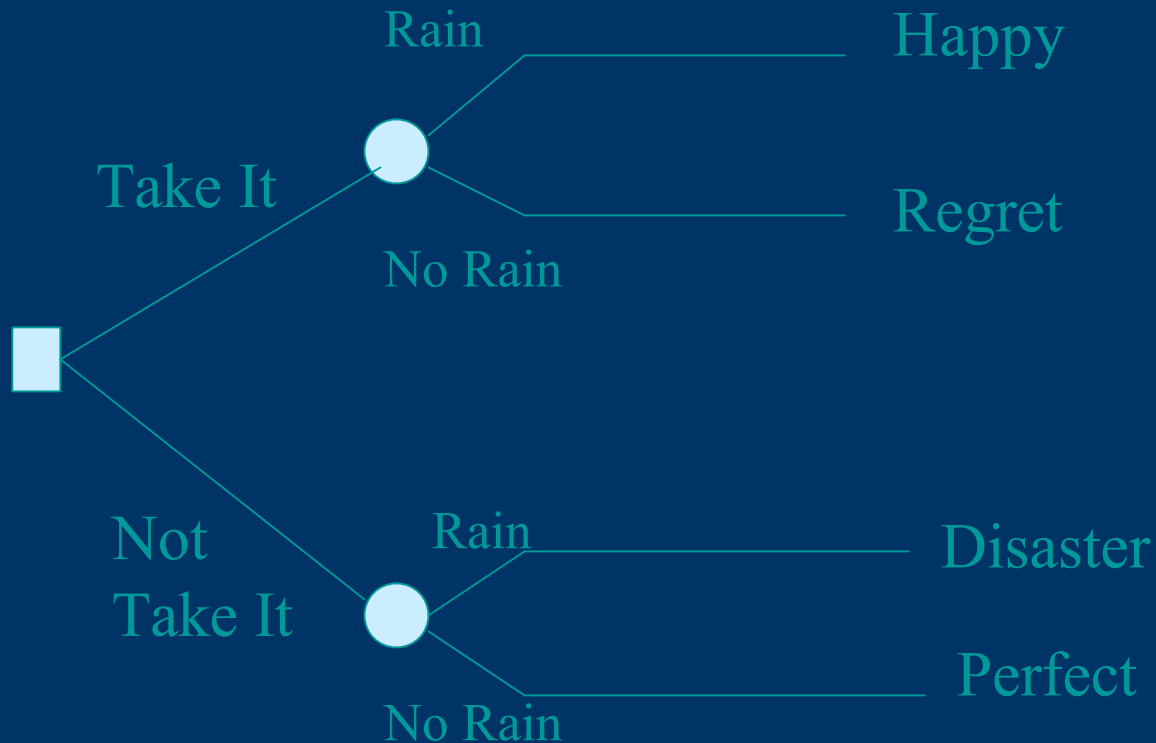
- Preferences between world states are captured by a *utility function*.
- Utility function assigns a single number to express the desirability of a decision or action.
- Utilities are combined with the probabilities of the states of the world to give an expected utility for each action.

Decision Making

- The principle of *maximum expected utility* says that a rational agent should choose an action that maximizes the agent's expected utility.
- View decision making in terms of
 - Beliefs/Uncertainties
 - Alternatives/Decisions
 - Objectives/Utilities

A Decision Problem

Should I Take an Umbrella?



General Approach -- Inference

- Identify possible states of the world (S_j).
- Assign prior probabilities $p(S_j)$
- Assign conditional probabilities $p(E_i|S_j)$ of the parameters that determine the states of the world.
- Digest any additional evidence $E = E_1 E_2 \dots$. Thus obtaining the posterior probabilities $p(S_j|E_i)$.

General Approach--Decisions

- Enumerate the possible decisions D_i for each state S_j
- Assign the utility function $U(D_i, S_j)$ that tells what you want to accomplish.
- Make that decision D_i that maximizes the expected utility over the posterior probabilities for S_j .

Policy Making

- Policies and decisions are often based on:
 - anecdotal information and opinions of a few consultants.
 - not on solid evidence, knowledge of prior experiences, or voice of the people.

The objective

- Develop techniques and tools to:
 - assist policymakers in their decisions and the World Bank staff in their development projects.
 - Enable citizens to voice their opinions and increase their influence in policymaking.

Motivating Examples

Some typical scenarios that policymakers deal with:

- Should we fund more scholarship programs?
- Is it worth adding more vocational schools?
- Should the government fund heart transplants?
- How did Korea reform its secondary education?

Basic Questions

- Three basic questions that policymakers face:
- What should we do?
- When and how should we do it?
- What result do we expect?

A Knowledge-based Approach

- In many “weak theory” domains such as medicine, law, and economics tasks are not algorithmic.
- Knowledge about problems are inherently case-based and prior experience is essential.
- Reasoning is not always based on a set of first principles.
- One deals with a new situation by applying, remembering, and modifying prior experience.

Case-based Reasoning (CBR)

- Reasoning is not modelled as a process that draws conclusions by chaining together generalized rules.
- Rather, new solutions are generated by retrieving the most relevant cases from a memory of specific prior episodes and adapting them to fit new situations.
- Reasoning is based on remembering.

What is a case?

- A case typically consists of:
 - The *problem* that describes the state of the world
 - The *solution* to the problem
 - The *outcome* when the solution was carried out.

Case-based Reasoning

- Once cases are identified and classified, the task is to select the right case that applies to the current situation.
- The CBR approach is based on two principles:
(a) similar problems have similar solutions; and
(b) problems tend to recur.
- A CBR system finds the most similar case for a particular situation.

An Example: India's Milk Market

Problem Description

In India in the 1950s, milk production could not keep pace with growing demand. Some milk vendors watered down the milk. Because there were many vendors, and brand names were not clearly established, vendors who did not dilute their milk could not command a premium and were squeezed out of the market. The result was an overall drop in milk quality.

An Example: India's Milk Market

Solution

The National Dairy Development Board in the early 1970's launched a multifaceted program that achieved the following:

- encouraged the creation of *dairy cooperatives*.
- rewarded quality through a pricing scheme.
- established *brand names*.
- created *incentives* for producing quality milk.

An Example: India's Milk Market

Outcome

- **By 1979 the incomes of a million milk producers had doubled.**
- **India became the world's third-largest producer of milk.**
- **Quality of milk was improved.**

Case-based Reasoning

- Two major functional parts to a case: its content and its context described by its indexes.
- A case's indexes are combinations of its important descriptors.
- Indexes are used for retrieval.








Learning and CBR

- A learner is interested in acquiring cases that helps him/her to compare and contrast various experiences.
- To do this the learner needs to label different experiences.
- This labelling process is referred to as indexing.

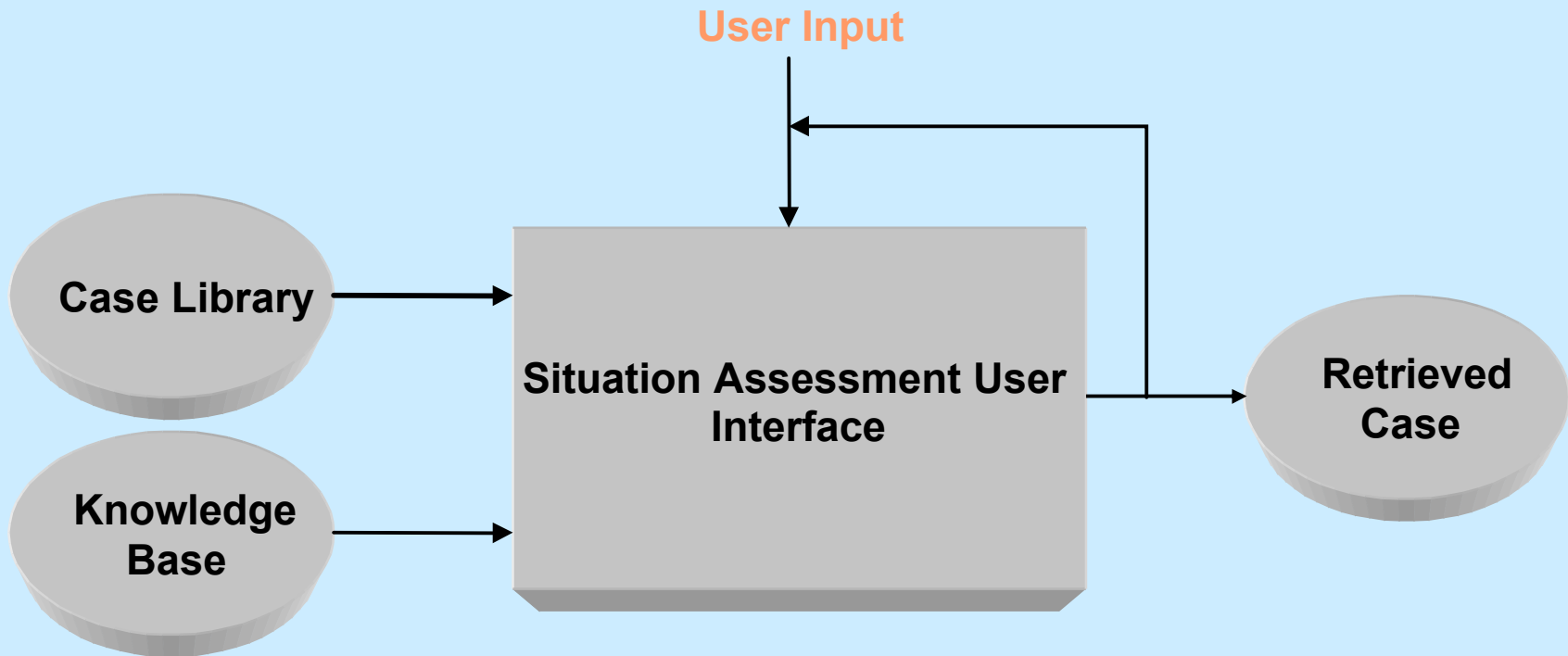
Indexing

- ❑ In information retrieval systems the indexing is tied to the *words* of the text.
- ❑ In case-based systems indexing is focused on the *meaning* of the text -- conceptual indexing.

Questions-Based Indexing

-  How did India become one of the World's largest producer of milk ?
-  What are the best ways to deal with fraud?
-  How do modern economies deal with verification and enforcement problem?
-  How do brand names provide quality assurance?
-  What are other top milk producing countries?
-  Why did the state intervene in the case of milk production in India?
-  What kinds of problems does government regulation create?

A Conversational System



Policymaking

- Two distinct phases to policymaking:
- A clear understanding of the problems.
- Deciding on a course of action.

A Method

- Represent Knowledge in terms of cases.
- Share the information through a dialogue.
- Help with the decision making through what-if scenarios.

Problems & Challenges

- Modelling value-judgements
- Selection of the right content and cases
- Semi-automated indexing

Summary

- Representation of knowledge in terms of cases
- Better user interfaces
- Improved quality of learning
- Decision making through exploring what-if scenarios.

What Next?

- Use of the simulation models for diagnostic purposes and scenario creation
- Use of multiple models
- Integration of case histories
- Integration of strategies
- Integration of local knowledge
- Data Mining