# Chapter 13: Knowledge Acquisition and Validation

## 13.1 Opening Vignette: American Express Improves Approval Selection with Machine Learning

**The Problem: Loan Approval**

- **85 to 90 % Predicted Accurately**
- **10 to 15 % in Gray Area**
- **Accuracy of Loan Officer's Gray Area Decisions were at most 50 %**

# The Solution

- **ES with Knowledge Acquisition Method of *Machine Learning***
- ***Rule Induction* Method**
- **Gray Area: Induced Decision Tree Correctly Predicted 70 %**
- **Induced Rules *Explain* Why Rejected**

# 13.2 Knowledge Engineering

- The art of bringing the principles and tools of AI research to bear on difficult applications problems requiring experts' knowledge for their solutions
- The technical issues of acquiring this knowledge, representing it and using it appropriately to construct and explain lines-of-reasoning are important problems in the design of knowledge-based systems
- The art of constructing intelligent agents is both part of and an extension of the programming art
- It is the art of building complex computer programs that represent and reason with knowledge of the world

- ***Narrow perspective:*** **knowledge engineering deals with knowledge acquisition, representation, validation, inferencing, explanation and maintenance**

- ***Wide perspective:*** **KE describes the *entire process* of developing and maintaining AI systems**

- **We use the Narrow Definition**
  - **Involves the cooperation of human experts**
  - **Synergistic effect**

# Knowledge Engineering Process Activities

- Knowledge Acquisition
- Knowledge Validation
- Knowledge Representation
- Inference
- Explanation and Justification
  - (Figure 13.1)

# 13.3 Scope of Knowledge

- *Knowledge acquisition* is the extraction of knowledge from sources of expertise and its transfer to the knowledge base and sometimes to the inference engine

- *Knowledge* is a collection of specialized facts, procedures and judgment rules

# Knowledge Sources

- Documented (books, manuals, etc.)
- Undocumented (in people's minds)
  - From people, from machines
- Knowledge Acquisition from Databases
- Knowledge Acquisition Via the Internet

# Knowledge Levels

- *Shallow* Knowledge (surface)
- *Deep* knowledge

- Can implement a computerized representation that is *deeper* than shallow knowledge (Example: Figure 13.3)
- Special knowledge representation methods (semantic networks and frames) to allow the implementation of deeper-level reasoning (abstraction and analogy): important expert activity
- Represent objects and processes of the domain of expertise at this level
- The relationships among objects are

# Major Categories of Knowledge

- Declarative Knowledge
- Procedural Knowledge
- Metaknowledge

# Declarative Knowledge

## Descriptive Representation of Knowledge

- Expressed in a factual statement
- Shallow
- Important in the initial stage of knowledge acquisition

# Procedural Knowledge

- Considers the manner in which things work under different sets of circumstances
  - Includes step-by-step sequences and how-to types of instructions
  - May also include explanations
  - Involves automatic response to stimuli
  - May also tell how to use declarative knowledge and how to make

- **Descriptive knowledge** relates to a specific object. Includes information about the meaning, roles, environment, resources, activities, associations and outcomes of the object

- **Procedural knowledge** relates to the procedures employed in the problem-solving process

# Metaknowledge

## Knowledge about Knowledge

- In ES, *Metaknowledge* refers to knowledge about the operation of knowledge-based systems
- Its reasoning capabilities

# 13.4 Difficulties in Knowledge Acquisition

- Problems in Transferring Knowledge
- Expressing the Knowledge
- Transfer to a Machine
- Number of Participants
- Structuring the Knowledge

# Other Reasons

- Experts may lack time or not cooperate
- Testing and refining knowledge is complicated
- Poorly defined methods for knowledge elicitation
- System builders may collect knowledge from one source, but the relevant knowledge may be scattered across several sources
- Collect documented knowledge rather than use experts
- The knowledge collected may be incomplete
- Difficult to recognize specific knowledge when mixed with irrelevant data
- Experts may change their behavior when observed and/or interviewed
- Problematic interpersonal communication between the knowledge engineer and the expert

# Overcoming the Difficulties

- Knowledge acquisition tools with ways to decrease the representation mismatch between the human expert and the program ("learning by being told")
- Simplified rule syntax
- Natural language processor to translate knowledge to a specific representation
- Impacted by the role of the three major participants
  - Knowledge Engineer
  - Expert
  - End user

- Critical
  - The ability and personality of the knowledge engineer
  - Must develop a positive relationship with the expert
  - The knowledge engineer must create the right impression
- Computer-aided knowledge acquisition tools
- Extensive integration of the acquisition efforts

# Required Skills and Characteristics of Knowledge Engineers

- Computer skills
- Tolerance and ambivalence
- Effective communication abilities
- Broad educational background
- Advanced, socially sophisticated verbal skills
- Fast-learning capabilities (of different domains)
- Must understanding organizations and individuals
- Wide experience in knowledge engineering
- Intelligence
- Empathy and patience
- Persistence
- Logical thinking
- Versatility and inventiveness
- Self-confidence

# 13.5 Methods of Knowledge Acquisition: An Overview

- **Manual**
- **Semiautomatic**
- **Automatic (Computer Aided)**

# Manual Methods - Structured Around Interviews

- Process (Figure 13.4)
- Interviewing
  - Structured
  - Semistructured
  - Unstructured
- Tracking the Reasoning Process
- Observing
- Manual methods: slow, expensive and sometimes inaccurate

# Semiautomatic Methods

- **Support Experts Directly (Figure 13.5)**
- **Help Knowledge Engineers**

# Automatic Methods

- **Expert's and/or the knowledge engineer's roles are minimized (or eliminated)**
- **Induction Method (Figure 13.6)**

# Knowledge Modeling

- The *knowledge model* views knowledge acquisition as the construction of a model of problem-solving behavior-- a model in terms of knowledge instead of representations

- Can ***reuse models*** across applications

# 13.6 Interviews

- **Most Common Knowledge Acquisition: Face-to-face Interview Analysis**
- **Types of Interviews**
  - Unstructured (Informal)
  - Structured

# Unstructured Interviews

- **Seldom provides complete or well-organized descriptions of cognitive processes because**
  - **The domains are generally complex**
  - **The experts usually find it very difficult to express some more important knowledge**
  - **Domain experts may interpret the lack of structure as requiring little preparation**
  - **Data acquired are often unrelated, exist at varying levels of complexity, and are difficult for the knowledge engineer to review, interpret and integrate**
  - **Few knowledge engineers can conduct an efficient unstructured interview**

- The knowledge engineer slowly learns about the problem
- Then can build a representation of the knowledge

- Knowledge acquisition involves
  - Uncovering important problem attributes
  - Making explicit the expert's thought process

# Unstructured Interviews

- Most Common Variations
  - Talkthrough
  - Teachthrough
  - Readthrough

# Structured Interviews

- Systematic goal-oriented process
- Forces an organized communication between the knowledge engineer and the expert
- Procedural Issues in Structuring an Interview (Table 13.1)

- Interpersonal communication and analytical skills are important

# TABLE 13.1 Procedures for Structured Interviews

- **The knowledge engineer studies available material on the domain to identify major demarcations of the relevant knowledge.**

- **The knowledge engineer reviews the planned expert system capabilities. He or she identifies targets for the questions to be asked during the knowledge acquisition session.**

- **The knowledge engineer formally schedules and plans (using a form) the structured interviews. Planning includes attending to physical arrangements, defining knowledge acquisition session goals and agendas, and identifying or refining major areas of questioning.**

- **The knowledge engineer may write sample questions, focusing on question type, level and questioning techniques.**

- **The knowledge engineer ensures that the domain expert understands the purpose and goals of the session and encourages the expert to prepare prior to the interview.**

- **During the interview the knowledge engineer follows guidelines for conducting interviews.**

- **During the interview the knowledge engineer uses *directional control* to retain the interview's structure.**

*Source*: Condensed from K. L. McGraw and B. K. Harbison-Briggs, *Knowledge Acquisition, Principles and Guidelines*, Englewood Cliffs, NJ: Prentice-Hall, 1989.

# Interviews - Summary

- Are important techniques
- Must be planned carefully
- Results *must* be verified and validated
- Are sometimes replaced by tracking methods
- Can supplement tracking or other knowledge acquisition methods

# Recommendation

**Before a knowledge engineer interviews *the* expert(s)**

1. **Interview a less knowledgeable (minor) expert**
   - **Helps the knowledge engineer**
     - **Learn about the problem**
     - **Learn its significance**
     - **Learn about the expert(s)**
     - **Learn who the users will be**
     - **Understand the basic terminology**
     - **Identify readable sources**
2. **Next read about the problem**
3. **Then, interview the expert(s) (much more effectively)**

# 13.7 Tracking Methods

- Techniques that attempt to *track* the reasoning process of an expert
- From cognitive psychology
- Most common formal method: ***Protocol Analysis***

# Protocol Analysis

- *Protocol*: a record or documentation of the expert's step-by-step information processing and decision-making behavior
- The expert performs a real task and verbalizes his or her thought process (think aloud)

**Summary (Table 13.2)**

**Advantages and Limitations (Table 13.3)**

## TABLE 13.2 Procedure of Protocol Analysis

- Provide the expert with a full range of information normally associated with a task.
- Ask the expert to verbalize the task in the same manner as would be done normally while verbalizing his or her decision process and record the verbalization on tape.
- Make statements by transcribing the verbal protocols.
- Gather the statements that seem to have high information content.
- Simplify and rewrite the collected statements and construct a table of production rules out of the collected statements.
- Produce a series of models by using the production rules.

*Source*: Organized from J. Kim and J. F. Courtney, " A Survey of Knowledge Acquisition Techniques and Their Relevance to Managerial Problem Domains," *Decision Support Systems 4*, October 1988, p. 273.

## TABLE 13.3 Advantages and Limitations of Protocol Analysis

| Advantages | Limitations |
| --- | --- |
| Expert consciously considers decision-making heuristics | Requires that the expert be aware of why he or she makes a decision |
| Expert consciously considers decision alternatives attributes, values | Requires that the expert be able to categorize major decision alternatives |
| Knowledge engineer can observe and analyze decision-making behavior | Requires that the expert be able to verbalize the attributes and values of a decision alternative |
| Knowledge engineer can record, and later analyze with the expert, key decision points | Requires that the expert be able to reason about the selection of a given alternative |
| | Subjective view of decision making<br>Explanations may not track with reasoning |

*Source*: K. L. McGraw and B. K. Harbison-Briggs, *Knowledge Acquisition, Principles and Guidelines*, Englewood Cliffs, NJ: Prentice-Hall, 1989, p. 217.

# 13.8 Observations and Other Manual Methods

- **Observations**
- **Observe the Expert Work**

# Other Manual Methods

- Case analysis
- Critical incident analysis
- Discussions with the users
- Commentaries
- Conceptual graphs and models
- Brainstorming
- Prototyping
- Multidimensional scaling
- Johnson's hierarchical clustering
- Performance review

# 13.9 Expert-driven Methods

- Knowledge Engineers Typically
  - Lack Knowledge About the Domain
  - Are Expensive
  - May Have Problems Communicating With Experts
- Knowledge Acquisition May be Slow, Expensive and Unreliable
- Can Experts Be Their Own Knowledge Engineers?

# Approaches to Expert-Driven Systems

- Manual
- Computer-Aided (Semiautomatic)

# Manual Method: Expert's Self-reports

## Problems with Experts' Reports and Questionnaires

1. Requires the expert to act as knowledge engineer
2. Reports are biased
3. Experts often describe new and untested ideas and strategies
4. Experts lose interest rapidly
5. Experts must be proficient in flowcharting
6. Experts may forget certain knowledge
7. Experts are likely to be vague

# Benefits

- May provide useful preliminary knowledge discovery and acquisition
- Computer support can eliminate some limitations

# Computer-aided Approaches

- To reduce or eliminate the potential problems
  - REFINER+ - case-based system
  - TIGON - to detect and diagnose faults in a gas turbine engine
- Other
  - Visual modeling techniques
  - New machine learning methods to induce decision trees and rules
  - Tools based on repertory grid analysis

# 13.10 Repertory Grid Analysis (RGA)

- Techniques, derived from psychology
- Use the classification interview
- Fairly structured
- Primary Method:

  Repertory Grid Analysis (RGA)

# The Grid

- Based on *Kelly*'s model of human thinking: Personal Construct Theory (PCT)
- Each person is a "personal scientist" seeking to predict and control events by
  - Forming Theories
  - Testing Hypotheses
  - Analyzing Results of Experiments
- Knowledge and perceptions about the world (a domain or problem) are classified and categorized by each individual as a personal, perceptual model
- Each individual anticipates and then acts

# How RGA Works

1. The expert identifies the *important objects* in the domain of expertise (interview)
2. The expert identifies the important *attributes*
3. For each attribute, the expert is asked to establish a bipolar scale with distinguishable characteristics (traits) and their opposites [see Table 13.4]
4. The interviewer picks any three of the objects and asks: What attributes and traits distinguish any two of these objects from the third? Translate answers on a scale of 1-3 (or 1-5)

## TABLE 13.4 RGA Input for Selecting a Computer Language

| Attributes | Trait | Opposite |
|---|---|---|
| Availability | Widely available | Not available |
| Ease of programming | High | Low |
| Training time | Low | High |
| Orientation | Symbolic | Numeric |

- **Step 4 continues for several triplets of objects**
- **Answers recorded in a Grid (Table 13.5)**
- **Expert may change the ratings inside box**
- **Can use the grid for recommendations**

## TABLE 13.5 Example of a Grid

| Attribute | Orientation | Ease of Program-ming | Training Time | Availa-bility |
|---|---|---|---|---|
| Trait<br>Opposite | Symbolic (3)<br>Numeric (1) | High (3)<br>Low (1) | High (1)<br>Low (3) | High (3)<br>Low (1) |
| LISP | 3 | 3 | 1 | 1 |
| PROLOG | 3 | 2 | 2 | 1 |
| $C^{++}$ | 3 | 2 | 2 | 3 |
| COBOL | 1 | 2 | 1 | 3 |

# Use of RGA in Expert Systems - Tools

- Expertise Transfer System (ETS)
  - (Now in AQUINAS)
- AQUINAS
- KRITON

# Other RGA Tools

- **PCGRID (PC-based)**
- **WebGrid**
- **Circumgrids**

# 13.11 Supporting the Knowledge Engineer

- Knowledge Acquisition Aids
- Special Languages
- Editors and Interfaces
- Explanation Facility
- Revision of the Knowledge Base
- Pictorial Knowledge Acquisition (PIKA)

- **Integrated Knowledge Acquisition Aids**
  - PROTÉGÉ-II
  - KSM
  - ACQUIRE
  - KADS (Knowledge Acquisition and Documentation System)
- **Front-end Tools**
  - Knowledge Analysis Tool (KAT)
  - NEXTRA (in Nexpert Object)

# 13.12 Machine Learning: Rule Induction, Case-based Reasoning, Neural Computing, and Intelligent Agents

- Manual and semiautomatic elicitation methods: slow and expensive
- Other Deficiencies
  - Frequently weak correlation between verbal reports and mental behavior
  - Sometimes experts cannot describe their decision making process
  - System quality depends too much on the quality of the expert and the knowledge engineer
  - The expert does not understand ES technology
  - The knowledge engineer may not understand the business problem
  - Can be difficult to validate acquired knowledge

# Computer-aided Knowledge Acquisition, or Automated Knowledge Acquisition Objectives

- Increase the productivity of knowledge engineering
- Reduce the required knowledge engineer's skill level
- Eliminate (mostly) the need for an expert
- Eliminate (mostly) the need for a knowledge engineer
- Increase the quality of the acquired knowledge

# Automated Knowledge Acquisition (Machine Learning)

- Rule Induction
- Case-based Reasoning
- Neural Computing
- Intelligent Agents

# Machine Learning

- Knowledge Discovery and Data Mining
- Include Methods for Reading Documents and Inducing Knowledge (Rules)
- Other Knowledge Sources (Databases)
- Tools
  - KATE-Induction

# Automated Rule Induction

- **Induction**: Process of Reasoning from Specific to General
- In ES: Rules Generated by a Computer Program from Cases
- Interactive Induction

## TABLE 13.6 Case for Induction - A Knowledge Map

## (Induction Table)

| Attributes | | | | | |
|---|---|---|---|---|---|
| Applicant | Annual Income ($) | Assets ($) | Age | Dependents | Decision |
| Mr. White | 50,000 | 100,000 | 30 | 3 | Yes |
| Ms. Green | 70,000 | None | 35 | 1 | Yes |
| Mr. Smith | 40,000 | None | 33 | 2 | No |
| Ms. Rich | 30,000 | 250,000 | 42 | 0 | Yes |

# Case-based Reasoning (CBR)

- For Building ES by Accessing Problem-solving Experiences for Inferring Solutions for Solving Future Problems
- Cases and Resolutions Constitutes a Knowledge Base

# Neural Computing

- **Fairly Narrow Domains with Pattern Recognition**
- **Requires a Large Volume of Historical Cases**

# Intelligent Agents for Knowledge Acquisition

## Led to

- **KQML (Knowledge Query and Manipulation Language) for Knowledge Sharing**
- **KIF, Knowledge Interchange Format (Among Disparate Programs)**

# 13.13 Selecting an Appropriate Knowledge Acquisition Method

- **Ideal Knowledge Acquisition System Objectives**
  - Direct interaction with the expert without a knowledge engineer
  - Applicability to virtually unlimited problem domains
  - Tutorial capabilities
  - Ability to analyze work in progress to detect inconsistencies and gaps in knowledge
  - Ability to incorporate multiple knowledge sources
  - A user friendly interface
  - Easy interface with different expert system tools
- **Hybrid Acquisition - Another Approach**

# 13.14 Knowledge Acquisition from Multiple Experts

- Major Purposes of Using Multiple Experts
  - Better understand the knowledge domain
  - Improve knowledge base validity, consistency, completeness, accuracy and relevancy
  - Provide better productivity
  - Identify incorrect results more easily
  - Address broader domains
  - To handle more complex problems and combine the strengths of different reasoning approaches
- Benefits And Problems With Multiple Experts (Table 13.7)

# Table 13.7 Benefits of and Problems with Participation of Multiple Experts

| Benefits | Problems |
|---|---|
| On the average, fewer mistakes by a group of experts than by a single expert | Groupthink phenomena |
| Several experts in a group eliminate the need for using a world-class expert (who is difficult to get and expensive) | Fear on the part of some domain experts of senior experts or a supervisor (lack of confidentiality) |
| Wider domain than a single expert's | Compromising solutions generated by a group with conflicting opinions |
| Synthesis of expertise | Waste of time in group meeting |
| Enhanced quality from synergy among experts | Difficulties in scheduling the experts |
| | Dominating experts (controlling, not letting others speak) |

# Handling Multiple Expertise

- Blend several lines of reasoning through *consensus methods*
- Use an *analytical approach* (group probability)
- Select one of several distinct lines of reasoning
- Automate the process
- Decompose the knowledge acquired into specialized knowledge sources

# 13.15 Validation and Verification of the Knowledge Base

- Quality Control
  - Evaluation
  - Validation
  - Verification

- Evaluation
  - Assess an expert system's overall value
  - Analyze whether the system would be usable, efficient and cost-effective
- Validation
  - Deals with the *performance* of the system (compared to the expert's)
  - Was the "right" system built (acceptable level of accuracy?)
- Verification
  - Was the system built "right"?
  - Was the system correctly implemented to specifications?

# Dynamic Activities

- Repeated each prototype update
- For the Knowledge Base
  - Must have the *right* knowledge base
  - Must be constructed properly (verification)
- Activities and Concepts In Performing These Quality Control Tasks (Table 13.8)

## TABLE 13.8 Measures of Validation

| Measure (Criteria) | Description |
|---|---|
| Accuracy | How well the system reflects reality; how correct the knowledge is in the knowledge base |
| Adaptability | Possibilities for future development, changes |
| Adequacy (or completeness) | Portion of the necessary knowledge that is included in the knowledge base |
| Appeal | How well the knowledge base matches intuition and stimulates thought and practicability |
| Breadth | How well the domain is covered |
| Depth | Degree of the detailed knowledge |
| Face validity | Credibility of knowledge |
| Generality | Capability of a knowledge base to be used with a broad range of similar problems |
| Precision | Capability of the system to replicate particular system parameters; consistency of advice; coverage of variables in knowledge base |
| Realism | Accounting for relevant variables and relations; similarity to reality |
| Reliability | Fraction of the ES predictions that are empirically correct |
| Robustness | Sensitivity of conclusions to model structure |
| Sensitivity | Impact of changes in the knowledge base on quality of outputs |
| Technical and operational validity | Quality of the assumed assumptions, context, constraints and conditions, and their impact on other measures |
| Turing Test | Ability of a human evaluator to identify if a given conclusion is made by an ES or by a human expert |
| Usefulness | How adequate the knowledge is (in terms of parameters and relationships) for solving correctly |
| Validity | Knowledge base's capability of producing empirically correct predictions |

*Source*: Adapted from B. Marcot, "Testing Your Knowledge Base," *AI Expert*, August 1987.

# Method for Validating ES

- Test
  1. The extent to which the system and the expert decisions agree
  2. The inputs and processes used by an expert compared to the machine
  3. The difference between expert and novice decisions

(Sturman and Milkovich [1995])

# 13.16 Analyzing, Coding, Documenting, and Diagramming

**Method of Acquisition and Representation**

1. Transcription
2. Phrase Indexing
3. Knowledge Coding
4. Documentation

(Wolfram et al. [1987])

# Knowledge Diagramming

- Graphical, hierarchical, top-down description of the knowledge that describes facts and reasoning strategies in ES
- Types
  - Objects
  - Events
  - Performance
  - Metaknowledge
- Describes the linkages and interactions among knowledge types
- Supports the analysis and planning of subsequent acquisitions
- Called conceptual graphs (CG)
- Useful in analyzing acquired knowledge

# 13.17 Numeric and Documented Knowledge Acquisition

- Acquisition of Numeric Knowledge
  - Special approach needed to capture numeric knowledge
- Acquisition of Documented Knowledge
  - Major Advantage: No Expert
  - To Handle a Large or Complex Amount of Information
  - New Field: New Methods That Interpret Meaning to Determine
    - Rules
    - Other Knowledge Forms (Frames for Case-Based Reasoning)

# 13.18 Knowledge Acquisition and the Internet/Intranet

- Hypermedia (Web) to Represent Expertise Naturally
- Natural Links can be Created in the Knowledge
- CONCORDE: Hypertext-based Knowledge Acquisition System

  Hypertext links are created as knowledge objects are acquired

# The Internet/Intranet for Knowledge Acquisition

- Electronic Interviewing
- Experts can Validate and Maintain Knowledge Bases
- Documented Knowledge can be accessed
- The Problem: Identify relevant knowledge (intelligent agents)
- Many Web Search Engines have intelligent agents
- Data Fusion Agent for multiple Web searches and organizing
- Automated Collaborative Filtering (ACF) statistically matches peoples' evaluations of a set of objects

# New Developments

- *WebGrid*: Web-based Knowledge Elicitation Approaches
- Plus Information Structuring in Distributed Hypermedia Systems

# 13.19 Induction Table Example

- **Induction tables (knowledge maps) focus the knowledge acquisition process**
- **Choosing a site for a hospital clinic facility (Section 13.6: Table 13.9)**

# TABLE 13.9: Induction Table (Knowledge Map) Example

| Population Density | Density over How Many Sq. mi | Number of Near (within 2 miles) Competitors | Average Family Income | Near Public Transportation? | Decision (Choices) |
|---|---|---|---|---|---|
| People / Square Mile | Numeric, Region Size | 0, 1, 2, 3, ... | Numeric, $ / Year | Yes, No | Yes, No |
| >= 2000 | >=4 | 0 | | | Yes |
| >=3500 | >=4 | 1 | | | Yes |
| | | >=2 | | | No |
| | | | <30,000 | | No |
| | | | | | |
| | | | | | |

- Row 1: Factors
- Row 2: Valid Factor Values and Choices (last column)

- Table leads to the prototype ES
- Each row becomes a potential rule
- Induction tables can be used to encode *chains of knowledge*

# Class Exercise: Animals

- Knowledge Acquisition
- Create Induction Table
  - I am thinking of an animal!
  - Question: Does it have a long neck? If yes THEN Guess that it is a giraffe.
  - IF not a giraffe, then ask for a question to distinguish between the two. Is it YES or NO for a giraffe? Fill in the new Factor, Values and Rule.
  - IF no, THEN What is the animal? and fill in the new rule.
  - Continue with all questions
  - You will build a table very quickly

# Induction Table (Knowledge Map)

| Factors Here | | | | | | | Decisions |
|---|---|---|---|---|---|---|---|
| Factor Values Here | | | | | | | Actual Choices Here |
| Rule 1 | | | | | | | |
| Rule 2 | | | | | | | |
| etc. | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

# Induction Table (Knowledge Map)

| | | | | | | | Decisions |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

# Summary

- Knowledge engineering: acquisition, representation, reasoning (inference) and explanation
- Knowledge available from many sources, some documented, some not
- Knowledge can be shallow or deep
- Knowledge acquisition is difficult
- Knowledge acquisition methods: manual, semi-automated and automated
- Primary manual approach is interviewing: completely unstructured to highly structured

- Experts' reasoning process can be tracked by several methods (protocol analysis)
- Observation of experts in action is usually limited
- New manual and/or computerized tools for self-knowledge acquisition
- Repertory grid analysis (RGA) is the most applied method of semiautomated interviews
- Many productivity tools for knowledge acquisition
- Rule induction examines historical cases and generates rules

- **Rule induction can be used by a system engineer, an expert, other system builder**
- **Benefits, limitations and problems in several experts**
- **Major methods of multiple experts: consensus methods, analytical approaches, selection of an appropriate line of reasoning, process automation and blackboard systems**
- **Knowledge base validation and verification - critical ES implementation success factors**
- **Many measures to determine knowledge validity**

- Automated knowledge acquisition methods are easier to validate and verify
- Knowledge collected must be analyzed and coded prior to its representation
- Case-based reasoning, neural computing, intelligent agents and other machine learning tools can enhance the task of knowledge acquisition
- The Internet/intranet is expanding the methods for performing knowledge acquisition

# Questions for the Opening Vignette

1. Why was the system's accuracy so much better than the human loan officers?
2. Why was an explanation facility so important here?
3. Why do you think the ES predicted much more accurately than the Loan Officers did?
4. For the ES, what are the implications when there are changes in the economic climate? Explain.
5. Why do you think so many test cases were needed?
6. Could the ES be used to train Loan Officers? Explain.
7. Because the rule induced decision tree is much more accurate, comb the literature and try to estimate how much money can be saved by denying predicted faulted loans.

# Group Exercises

## Interview a Decision Maker

1. Which interviewing technique?
2. What problems encountered?
3. What problems occurred because a group interview, not a dialog?
4. What personality traits helped and hindered the group, and the decision maker? Why?
5. If the decision maker actually makes a decision while you are interviewing him/her (or shortly after), how he/she reached the conclusion.
6. Report your findings in a report. Compare results to other groups'.

# Tables for the Exercises

## For Exercises 1, 2, 4

- Table 13.10 for Exercise 1
- Table 13.11 for Exercise 2
- Table 13.12 for Exercise 4

# TABLE 13.10 Communication between Expert and Knowledge Engineer

| | Type of Communication | | | | |
|---|---|---|---|---|---|
| Method | Face-to Face Contact | Written Communications | Continuing for a Long Time | Time Spent by Expert | Time Spent by Knowledge Engineer |
| Interview analysis | | | | | |
| Observations of experts | | | | | |
| Questionnaires and expert report | | | | | |
| Analysis of documented knowledge | | | | | |

## TABLE 13.11 Comparisons of Automated Rule Induction and Interactive Methods

| Method/Tool | Time of Expert | Time of Knowledge Engineer | Skill of Knowledge Engineer |
| --- | --- | --- | --- |
| Rule induction | | | |
| Auto-Intelligence | | | |
| Smart editors | | | |
| Expertise Transfer System | | | |

## TABLE 13.12 Admission Cases

| Case # | GMAT | GPA | Decision |
|---|---|---|---|
| 1 | 510 | 3.5 | Yes |
| 2 | 620 | 3.0 | Yes |
| 3 | 580 | 3.0 | No |
| 4 | 450 | 3.5 | No |
| 5 | 655 | 2.5 | Yes |