Chapter 10

Knowledge Elicitation – Converting Tacit Knowledge to Explicit
Chapter Objectives

- Introduce the student to capturing tacit knowledge from human sources and convert it into explicit knowledge.
- Introduce the student to the various stages of the traditional one-on-one interview and how they can be managed for effectiveness.
- Other elicitation techniques such as observation, role-reversal, etc.
- The variations of the one-on-one interview when more than one person participates.
Section 10.1 - Objectives

• Introduction of chapter contents
Figure 10.1

Knowledge Elicitation

Knowledge Capture = Knowledge Elicitation + Knowledge Representation
Section 10.2 - Objectives

- Introduce the basic approach to face-to-face knowledge elicitation from an expert: the one-on-one interview.
- Introduce the Output-Input-Middle method for organizing captured knowledge
- Introduce alternate knowledge elicitation techniques
- Introduce variations to the one-on-one interview when more than two participants are present.
Basic One-On-One Interviews: Kickoff Interview

- Objective: establish good rapport with the expert
- Demonstrate to the expert that the KE has made an honest attempt to gain familiarization with the domain before the meeting
- Typical agenda (max 1 hour):
  - Introduction and light conversation
  - Explanation of the objectives of the elicitation process
  - Discussion of the importance of the project
  - Discussion of what is expected of the expert, and what the expert can expect from the KE
  - Identification of reading materials the expert recommends for the KE to review
  - Scheduling of subsequent meetings
Basic One-On-One Interviews: General Knowledge-Gathering Sessions

- One kind of **knowledge elicitation session**
- Objective: learn general principles about the domain from the expert
  - Better understand the subject matter
  - Better understand the expert’s opinions and viewpoints on the domains
- Wide-ranging, emphasizing breadth
- Knowledge gathered probably will not be explicitly expressed
- Relieves some of the burden from the expert, by not requiring a continual definition of every term used
- Facilitates **open-ended questions** which
  - require discussion
  - cannot be answered simply with a yes, no, simple term, or number
- 1-2 hours per session
Basic One-On-One Interviews: Specific Problem-Solving, Knowledge-Gathering Sessions

- One kind of **knowledge elicitation session**
- Objective: learn how the expert solves specific problems or answers questions in the domain
- Highly directed, emphasizing depth instead of breadth of coverage
- Knowledge gathered probably will be explicitly expressed using the system’s knowledge representation language
- Ask many **close-ended questions** which
  - are quite specific
  - can be answered simply with a yes, no, simple term, or number
Basic One-On-One Interviews: Knowledge Elicitation Sequence

- **Output-Input-Middle method**
  - **Output**
    - Identify the answers or solutions to the problem under discussion (goals)
    - KE should focus on understanding subtle differences between goals
  - **Input**
    - Identify the sources of information that the expert uses to deduce the solution/answer
    - KE should make sure how these inputs are identified, determined, or generated is known and understood
  - **Middle**
    - Determine the links between the inputs and outputs
    - These connections represent the core of the expert’s knowledge
    - Some inputs may not be required initially, but may be requested later after the initial inputs are interpreted
    - Intermediate goals/hypotheses may be required to complete the connections
Basic One-On-One Interviews: Weaknesses

- The Q&A interview is not always the most efficient means of eliciting knowledge from an expert.
- In some domains, considerable expertise is documented in instruction manuals or books:
  - eg, maintenance manuals for automobile diagnosis.
- Sometimes even cooperative experts have difficulty articulating their expertise.
- Other elicitation techniques can be used when appropriate:
  - Observational elicitation
  - Role reversal.
Observational Elicitation

• KE observes the expert at work, trying to understand and duplicate the expert’s problem-solving methods

• Types:
  - Quiet on-site observation
  - On-site observation with discussion
  - Exercising the expert
  - Problem description and analysis
Observational Elicitation: Quiet on-site observation

- KE cannot question experts while they work
- Pros:
  - Experts’ train of thought is not continually interrupted by questions, so they can proceed at their most effective and realistic form
- Cons:
  - Lack of interaction leaves KE wondering about the solution approaches taken by the expert
  - If expert is asked to talk out loud as they work, can make experts self-conscious causing them to alter it or to create a verbalization that is much more or less complex than what they are actually doing
- Should be used:
  - to get a feel for the total magnitude of the problem-solving process
  - to verify (or reject) that a hypothesized approach is in use
- Should not be used:
  - to obtain details about the process
- Q&A session should follow
Observational Elicitation:
On-site observation with discussion

• KE may interact with the experts while they work
• Pros:
  ◦ Permits KE to better probe the process observed
• Cons:
  ◦ Expert may become distracted by the questions and not follow the normal procedure
• Should be used:
  ◦ when the observed task does not significantly challenge the expert’s problem-solving abilities (eg, is fairly routine)
• Should not be used:
  ◦ when the expert needs to struggle to reach a solution
    ▪ Symptoms: uneasiness, hesitation in decision-making, refusing to create a solution in front of the KE
• Q&A session should follow
Observational Elicitation: Exercising the expert

- In some domains, problems arise only seldom and unpredictably
  - Even when problems arise frequently, the difficulty level of the usual problems may not be sufficiently high
- Impedes knowledge elicitation by observation
- In such cases, KE may prepare **cases** of varying difficulty from historical data
- Presented to expert in an “off-line” environment to observe the expert’s methodology
- May also be used to supplement a case library for CBR
- Improvements to elicit experts’ abilities to provide additional information about their problem-solving expertise: [Hoffman 1987]
  - **Limited information tasks**: A routine task is performed, but the expert is not provided certain information that is typically available
  - **Constrained processing tasks**: A routine task is performed, but the expert must execute it under some constraint (eg, within a limited amount of time)
Observational Elicitation: Problem description and analysis

- Sometimes it is useful to observe cases that are classical problems, rather than real or historical cases
  - eg, cases typically discussed and analyzed by instructors in classroom situations
  - designed/chosen because they illustrate important or significant relationships within the domain that every problem solver should possess
- Normally such cases are selected by the expert
  - But occasionally the KE may find them useful to select when questioning the expert
- KE should make sure the expert explains the rationale behind distinguishing these problems as classics: what are the key relationships/features that make these cases significant?
- May also be used to supplement a case library for CBR
Role Reversal Techniques

- KE acts as the expert (pseudoexpert)
- The pseudoexpert attempts to solve a problem in the presence of the true expert (role-playing)
- The true expert questions the pseudoexperts about what they are doing and why
  - Like the observation process, but the with roles reversed
- May be used when:
  - KE already has a significant understanding of the problem-solving process
  - KE wishes to verify correctness of understanding
- Can clarify, modify, and provide significant new knowledge not previously uncovered by the KE
Team Interviewing

• Under some circumstances, interviewing may involve more than one KE and one expert

• Types:
  ♦ One-on-many
  ♦ Many-on-one
  ♦ Many-on-many
Team Interviewing: One-on-many

- Common when several experts work closely together
- Each expert may be specialized in slightly different areas, in complementary fashion
- If differences of opinion arise during a discussion, good chance of resolving them immediately and amicably
  - Typically in such an environment, this immediately uncovers a deeper level of knowledge (benefiting both KE and experts)
- Cons:
  - Sometimes the experts do not get along; can undermine team’s productivity
  - Can be redundant especially in general knowledge-gathering sessions, which is wasteful of experts’ time
  - Inexperienced KEs may be overwhelmed by multiple experts
  - Even experienced KEs may be exhausted quickly, since the KE must maintain concentration while each expert can drift in and out of “high gear”
Team Interviewing: Many-on-many

• Pros:
  - Few-on-few interviews may realize the benefits of both one-on-many and many-on-one interviews – synergism between experts as well as multiple observer perspectives
    ▪ Only holds for few-on-few interviews, eg, two-on-two or two-on-three
  - Sometimes unavoidable to external pressures (eg, time constraints dictated by management)

• Cons:
  - Difficult to accomplish anything with larger groups
  - High redundancy is wasteful of experts’ and KEs’ time
Team Interviewing: Many-on-one

• Pros:
  ◆ Multiple sets of eyes and ears are better than one
  ◆ Each KE can subsequently provide an alternative perspective about what happened during the interview, leading to a clearer picture

• Cons:
  ◆ The single expert often feels overwhelmed by the multiple KEs – may become more defensive
  ◆ Little chance for synergism, since no one else present has the expert’s level of domain understanding
  ◆ Even a cooperative KE easily gets exhausted quickly
Section 10.3 - Objectives

• Introduce the concept of repertory grids as a tool to facilitate the elicitation of knowledge from a human expert

• Provide a detailed example of how an automated knowledge elicitation system that uses repertory grids would operate
Repertory Grids

- A **repertory grid** is a list of specific characteristics of a domain that are to be evaluated by an expert
  - Mathematically: an attribute-value vector
  - Attributes are also sometimes called elements or labels
  - Values can be binary or a range of values
  - A **construct** is an attribute-value pair (along with the specification of the range, ie, set of allowed values)
- Based on Kelly’s [1955] theory of personal constructs in clinical psychology
  - Designed to improve the effectiveness of clinical sessions with a patient
  - Individuals perceive the world from a different and changing perspective
  - A model is built for particular persons that represents their views of the world, which is updated to represent the person’s beliefs as they are revised
- Adopted in a number of knowledge elicitation tools during the 1980s and 1990s
Table 10.1 Repertory Grid

<table>
<thead>
<tr>
<th>ELEMENTS 10, CONSTRUCTS 14, RANGE 1–5</th>
</tr>
</thead>
<tbody>
<tr>
<td>PURPOSE: Staff appraisal</td>
</tr>
<tr>
<td>Staff member No.</td>
</tr>
<tr>
<td>----------------------------</td>
</tr>
<tr>
<td>1 Intelligent</td>
</tr>
<tr>
<td>2 Willing</td>
</tr>
<tr>
<td>3 New boy</td>
</tr>
<tr>
<td>4 Little supervision</td>
</tr>
<tr>
<td>5 Motivated</td>
</tr>
<tr>
<td>6 Reliable</td>
</tr>
<tr>
<td>7 Mild</td>
</tr>
<tr>
<td>8 Idea person</td>
</tr>
<tr>
<td>9 Self-starter</td>
</tr>
<tr>
<td>10 Creative</td>
</tr>
<tr>
<td>11 Helpful</td>
</tr>
<tr>
<td>12 Professional</td>
</tr>
<tr>
<td>13 overall rating high</td>
</tr>
<tr>
<td>14 Messer</td>
</tr>
</tbody>
</table>

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Repertory Grids

- Automated tools exploit the idea of repertory grids by trying to help elicit:
  - what attributes are important for the domain
  - what range of values the attributes should have
### Table 10.2 Automobile Selection Grid

<table>
<thead>
<tr>
<th>Car</th>
<th>High-Perform?</th>
<th>Cost</th>
<th>Size</th>
<th>Functional?</th>
<th>Type</th>
<th>Fuel-efficient?</th>
<th>Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-911</td>
<td>yes</td>
<td>High</td>
<td>small</td>
<td>no</td>
<td>coupe</td>
<td>no</td>
<td>fast</td>
</tr>
<tr>
<td>Van</td>
<td>no</td>
<td>Medium</td>
<td>Large</td>
<td>yes</td>
<td>van</td>
<td>yes</td>
<td>slow</td>
</tr>
<tr>
<td>Caddy</td>
<td>no</td>
<td>High</td>
<td>Large</td>
<td>yes</td>
<td>sedan</td>
<td>no</td>
<td>medium</td>
</tr>
<tr>
<td>Focus</td>
<td>no</td>
<td>Low</td>
<td>small</td>
<td>yes</td>
<td>sedan</td>
<td>yes</td>
<td>slow</td>
</tr>
<tr>
<td>Miata</td>
<td>yes</td>
<td>High</td>
<td>small</td>
<td>no</td>
<td>coupe</td>
<td>yes</td>
<td>fast</td>
</tr>
<tr>
<td>M-B</td>
<td>yes</td>
<td>High</td>
<td>large</td>
<td>yes</td>
<td>sedan</td>
<td>no</td>
<td>fast</td>
</tr>
<tr>
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<td>medium</td>
<td>yes</td>
<td>sedan</td>
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<td>fast</td>
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<tr>
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<tr>
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<td>medium</td>
<td>yes</td>
<td>truck</td>
<td>yes</td>
<td>slow</td>
</tr>
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</table>
Repertory Grids

- Knowledge captured in repertory grids is rarely sufficient to build a complete knowledge-based system
  - but provides an excellent starting point to simplify the KEs’ job to be one of refinement, instead of bulk knowledge capture

- Excellent means of acquiring knowledge that has the following characteristics:
  - It is easily characterized as attribute-value pairs
  - The values can vary over a range covering two extremes
  - Certain characteristics of the object of knowledge can be easily defined
  - The knowledge centers about knowing how an object fits within this template
Section 10.4 – Objectives
(skip section)

• Introduces techniques to automate the knowledge acquisition process when the human knowledge is resident in databases
• Provides a detailed example of this approach
Figure 10.2
Table 10.3

<table>
<thead>
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<th>Component Name</th>
<th>Description</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>PW3</td>
<td>Power Supply</td>
<td>VDC</td>
</tr>
<tr>
<td>OP-AMP2</td>
<td>Operational Amplifier</td>
<td>Volts</td>
</tr>
<tr>
<td>R3</td>
<td>Resistor</td>
<td>Ohms</td>
</tr>
<tr>
<td>R4</td>
<td>Resistor</td>
<td>Ohms</td>
</tr>
<tr>
<td>R5</td>
<td>Resistor</td>
<td>Ohms</td>
</tr>
</tbody>
</table>
### Table 10.4

<table>
<thead>
<tr>
<th>Comp. Name</th>
<th>Connect pt.</th>
<th>Comp. Name</th>
<th>Connect pt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>PW3</td>
<td>+</td>
<td>R3</td>
<td>A</td>
</tr>
<tr>
<td>PW3</td>
<td>–</td>
<td>R4</td>
<td>A</td>
</tr>
<tr>
<td>R3</td>
<td>b</td>
<td>OP-AMP2</td>
<td>I</td>
</tr>
<tr>
<td>R4</td>
<td>b</td>
<td>OP-AMP2</td>
<td>J</td>
</tr>
<tr>
<td>R4</td>
<td>b</td>
<td>R5</td>
<td>A</td>
</tr>
<tr>
<td>OP-AMP2</td>
<td>O</td>
<td>R5</td>
<td>B</td>
</tr>
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</table>
Table 10.5

<table>
<thead>
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<th>Net#</th>
<th>Component name</th>
<th>Connect point</th>
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<tbody>
<tr>
<td>026</td>
<td>PW3</td>
<td>+</td>
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<td>OP-AMP2</td>
<td>I</td>
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<tr>
<td>028</td>
<td>R5</td>
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<td>R4</td>
<td>A</td>
</tr>
<tr>
<td>030</td>
<td>PW3</td>
<td>–</td>
</tr>
</tbody>
</table>
Section 10.5 - Objectives

- Summarize the chapter
- Provide Key terms
- Provide Review Questions
- Provide Review Exercises
Conclusions

• The student should be familiar with:
  - How to conduct a one-on-one interview with an expert to elicit her knowledge.
  - Alternative techniques for knowledge elicitation and when it is appropriate to use them.
  - Tools that can facilitate the knowledge elicitation process from an expert.
  - Techniques to automate the knowledge capture process from electronic databases.
Chapter 10

Knowledge Elicitation – Converting Tacit Knowledge to Explicit