Knowledge Engineering
Semester 2, 2004-05

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Lecture 1 – Introduction
11th January 2005
General information

- Lecturer: Michael Rovatsos (mrovatso@inf, AT 3.12)
- Lecture times: Tue/Fri 3-3:50 p.m. AT Lecture Theatre 3
- Assessment:
  - Two assessed practicals counting 15% each
  - Final exam paper counting 70%
- Module Web page:
  - www.inf.ed.ac.uk/teaching/courses/ke
- Check Web page for announcements and materials
“Health warning”

- This course will cover formal material
- The slides are not a summary of the lecture (notion of “lecture” misleading)
- Making a KE DVD is much cheaper than this
  ➔ make use of opportunity for interaction!
- Idea: You do the work anyway, why not do as much as possible of it in class?
- If you want to come, be punctual and stay throughout
### What is knowledge?

- **Knowledge** is a condensed presentation of information, which in turn is structured, contextualised raw data.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Example</th>
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<tbody>
<tr>
<td><strong>Data</strong></td>
<td></td>
</tr>
<tr>
<td>uninterpreted raw signal</td>
<td>... – – – – ...</td>
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<tr>
<td><strong>Information</strong></td>
<td></td>
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<tr>
<td>data + context meaning</td>
<td>SOS</td>
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<tr>
<td><strong>Knowledge</strong></td>
<td></td>
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<tr>
<td>purpose attached</td>
<td>emergency</td>
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<tr>
<td>generative for action</td>
<td>start rescue</td>
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<tr>
<td>creates new information</td>
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Different views

- Nature and purpose of knowledge:
  - theoretical: knowledge as “justified, true belief”
  - practical: knowledge as the “intellectual machinery” to achieve a problem-solving goal

- Symbol system vs. physical grounding hypothesis
  - Is inference on symbols representing the world sufficient to solve real-world problems . . .
  - . . . or are these symbolic representations irrelevant as long as the agent is successful in the physical world?
  - “Elephants don’t play chess” (or do they?)
Classifying knowledge

- By knowledge source: **Empirical** vs. **theoretical** knowledge
- By knowledge orientation: **Object-level** vs. **meta-level**
- Other categories:
  - Global vs. local
  - Explicit vs. tacit
  - Complete vs. incomplete
  - Certain vs. uncertain
  - Accessible vs. inaccessible
  - Fixed vs. volatile
  - Declarative vs. procedural
Exercise

Consider the following statements. What kinds of knowledge do they describe?

- John is a great pool player. He always wins against his mates.
- Mary is great at physics. Her understanding of quantum theory baffles her teachers.
- Man has proven capable of travelling to unexplored planets.
- Reuters news reports are always up to date with what is happening in the world.
Knowledge-based systems

- Knowledge-based systems (KBS) are intelligent problem solvers that represent and reason about domain knowledge.

- **Intelligent problem solving** maps domain space onto solution space using knowledge and problem data.

- Core of a KBS:
  - Data: specific, volatile & short-term information
  - Knowledge: general, stable & long-term information

- Symbolic AI view: knowledge is represented using symbols that can be manipulated by a computer program.
Knowledge in KBS

- **Domain knowledge**: knowledge about the domain of discourse
  - objects and relationships between them, domain facts, domain rules, domain types
- **Inference knowledge**: knowledge about reasoning operations on domain knowledge
- **Task knowledge**: goals of the KBS, their decomposition, control issues
- **Example**: Medical domain
  - **Domain**: e.g. symptoms and diseases
  - **Inference**: e.g. procedures “hypothesise” and “verify”
  - **Task**: e.g. diagnosis, clinical test
Knowledge Engineering

- **Knowledge Engineering (KE)** concerns the basic issues involved in building and using KBS, i.e.
  - acquisition
  - representation
  - explanation
  - validation

of knowledge in a KBS
Knowledge Engineering Process

- Data/Information
- Learner
- Knowledge
- User
- Provider/Validator
- Modeller
- KBS
- Developer
- Formal Representation

Informatics UoE
Knowledge Engineering
Central KE tasks

- **Learning**: Acquire knowledge from experts/examples (combined with prior knowledge?) with or without supervision.
- **Modelling**: Represent knowledge in computer-readable format for which appropriate *inference* methods exist.
- **Development**: Design/Implement a KBS that solves the problem at hand.
- **Validation**: Test the performance of the system according to some performance measure.
KE: The Human Interface

- Interaction btw. human and KE important in two stages: knowledge acquisition and explanation

- Knowledge acquisition:
  - IDENTIFY
  - EVALUATE
  - CONCEPTUALISE
  - FORMALISE
  - IMPLEMENT

- Requirements, concepts, representations

- Explanation
  - Convince end user that reasoning is correct
  - Convince engineer that the system is working

- Two approaches: trace-based vs. logic-based (trade-off btw. control and clarity)
Exercise

*What are the pros and cons of the KE endeavour?*

+ Make use of knowledge in an organisation regardless of (fluctuating) individual human experts
+ Support discovery of new knowledge through automation
+ Create systems that are more comprehensible/natural for humans
+ Unbiased, rational “thinking” of KBS
  – Great cost, esp. knowledge acquisition (bottleneck)
  – No replacement of human intelligence (e.g. creativity)
  – Dependence on technology
Course outline

1. Knowledge Acquisition
   ▶ Inductive learning of symbolic knowledge

2. Knowledge Representation & Reasoning
   ▶ Different AI-based methods for representing and reasoning about knowledge (logic, ontologies, uncertainty etc.)

3. Knowledge Synthesis
   ▶ Closed systems view: knowledge-based software synthesis
   ▶ Open systems view: Semantic Web, software agents & multiagent systems

4. Knowledge Evolution
   ▶ Combining existing knowledge with new information
   ▶ Knowledge engineering methodologies
Summary

▶ What is knowledge?
▶ What are knowledge-based systems?
▶ What is knowledge engineering?
▶ What are its most important aspects?
▶ Which of them will be dealt with in this course?