Description Logics

Introductory Lecture

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- Class home page:
  http://www.cs.man.ac.uk/~franconi/dl/course/2002/
  - All relevant information about the course.
  - Slides, lecture by lecture.
  - Downloadable reference articles.

- Suggested book on logic:

- Various scientific articles on the topic will be referenced during the course.
Systems ↔ Agents

Environment ↔ Agent

- Percepts
- Actions
- Effectors
- Sensors
An agent

Consider, e.g., the task of designing an automated vehicle:

**Percepts:** video, accelerometers, gauges, engine sensors, keyboard, GPS, . . .

**Actions:** steer, accelerate, brake, horn, speak/display, . . .

**Goals:** safety, reach destination, maximize profits, obey laws, passenger comfort, . . .

**Environment:** US urban streets, freeways, traffic, pedestrians, weather, customers, . . .
Rational Agents

An Agent as Reasoning module of a Rational Agent.

[Diagram showing the interaction between the world, user, and agent reasoning process]
Intelligent Agents

- An *Intelligent Agent* is an entity that perceives and acts according to an *internal declarative body of knowledge*.

- Abstractly, an agent is a function from percept histories and internal declarative knowledge to actions:

  \[ f : \mathcal{P}^* \times \mathcal{K} \rightarrow \mathcal{A} \]

  For any given class of environments and tasks, we seek the agent (or class of agents) with the best performance
Intelligent Agents

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• An Intelligent Agent as *Representation and Reasoning* module: a *logic*.

• *Logic*: a well formalized part of agent *knowledge* and *reasoning*. 
Non-Intelligent Agents: Reflex Agents

Agent

Sensors

What the world is like now

Condition-action rules

What action I should do now

Effectors

Environment
The goal of an Intelligent Information Agent is to manage, process, and access information – e.g., a database system.
The goal of an *Intelligent Information Agent* is to manage, process, and access Information – e.g., a database system.
The Architecture of an Intelligent Information Agent

Diagram:
- Conceptual Schema
- Logical Schema
- Database
The Architecture of an Intelligent Information Agent

Integrity Constraints

Conceptual Schema

Logical Schema

Database
The Architecture of an Intelligent Information Agent

Diagram:
- Integrity Constraints
  - Conceptual Schema
- Logical Schema
- Database
- Query
- Result
The Architecture of an Intelligent Information Agent
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Deduction

Integrity Constraints

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Query Result

Query

Result
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Result
The Architecture of an Intelligent Information Agent
The Architecture of an Intelligent Information Agent

- Deduction
  - Integrity Constraints
    - Conceptual Schema
- Logical Schema
- Query
- Database
- Result

Diagram showing the architecture of an intelligent information agent with components such as deduction, integrity constraints, conceptual schema, logical schema, query, and database.
The Architecture of an Intelligent Information Agent

Diagram showing the relationship between the Data Level, Information Level, Knowledge Level, Logical Schema, Conceptual Schema, Integrity Constraints, Deduction, Query, and Result.

- Data Level
- Information Level
- Knowledge Level
- Logical Schema
- Conceptual Schema
- Integrity Constraints
- Deduction
- Query
- Result
Reasoning at the Conceptual Level

![Diagram showing relationships between concepts: Italian, Lazy, Mafioso, LatinLover, ItalianProf. The relationships indicate disjointness and completeness.]
Reasoning at the Conceptual Level

\[
\text{ItalianProf} \implies \text{LatinLover}
\]
Processing Knowledge = “Reasoning”

Representation alone is not useful.

We want to be able to access represented knowledge and to *process* it.

- access alone is, in general, insufficient

- *implicit* knowledge has to be made explicit

   ~→ *deduction methods*

   - the results should only depend on the semantics . . .
   - and not on accidental syntactic differences in representations
Logic

A logic allows the axiomatization of the domain information, and the drawing of conclusions from that information.

- Syntax
- Semantics
- Logical inference = reasoning
Important Questions

- **Expressive Power** of representation language
  - able to *represent* the problem

- **Correctness** of entailment procedure
  - *no false* conclusions are drawn

- **Completeness** of entailment procedure
  - *all correct* conclusions are drawn

- **Decidability** of entailment problem
  - there exists a (terminating) algorithm to compute entailment

- **Complexity**
  - resources needed for computing the solution
What is a Logic

Clearly distinguish the definitions of:

• the *formal language*
  • Syntax
  • Semantics
  • Expressive Power
• the *reasoning problem* (e.g., entailment)
  • Decidability
  • Computational Complexity
• the *problem solving procedure*
  • Soundness and Completeness
  • (Asymptotic) Complexity
The ideal Logic

- Expressive
- With decidable reasoning problems
- With sound and complete reasoning procedures
- With efficient reasoning procedures – possibly sub-optimal
Goals of research in the field

- Study how declarative knowledge can be formally defined using a logic-based approach.
- Give a computational account to it, in order to reproduce it in a computing device.
Main topics of the course

- review of Classical Logic
- Structural Description Logics
- Propositional Description Logics
- Description Logics and Logics
- Description Logics and Databases
Conclusions

• A warning
  • Rigorous and formal course
Conclusions

• A warning
  • Rigorous and formal course

• Two promises
  • Many examples
  • Only few main important topics