MSc Knowledge Engineering: A List of Topics

Michael Rovatsos

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Introduction

- Definition and types of knowledge

- What are Knowledge-Based Systems? What is Knowledge Engineering?

- The Knowledge Engineering process

- The human interface

- Critique of KE

Knowledge Acquisition

Inductive Learning

- Definition, what are hypothesis, target concepts, hypothesis spaces

- How are IL methods described?

- Ockham's razor, notions of consistency, realisability, noise overfitting

Decision Tree Learning

- What are DTs? How expressive are they?

- The Decision Tree Learning algorithm

- Attribute selection heuristics

- Validation techniques

Version-Space Learning

- Candidate definitions, describing hypotheses with logical formulae

- Current-best hypothesis search

- Version-Space Learning algorithm

- Updating the version space

Knowledge Representation & Reasoning

Logic Recap

- Propositional logic: truth tables, inference rules, resolution

- First-order logic: predicates, quantifiers, substitution, unification, resolution (idea)

Ontologies

Basics

- Definition, categories, upper ontologies, (multiple) inheritance

- Physical composition (part-of relation, logical minimisation)

- Measurements (quantitative vs. qualitative)

- Substances and objects (individuation problem)

- Expressing change (situation calculus, fluents, the frame problem(s), successor-state axioms

Category Reasoning Systems

- Semantic Networks (inheritance, relations, problems of binary relations, reification, default reasoning by overriding, shortcomings)

- Description Logics (reasoning about categories with simple logics)

Reasoning with Default Information

- Closed-world assumption/unique names assumption, negation as failure

- Non-monotonic reasoning

- Circumscription (model preference, prioritised circumscription)

- Default logic (default rules, extensions)

Model-Based Reasoning

- A case study in KR&R

- What is MBR?

- The General Diagnostic Engine

- Minimal candidates, candidate discrimination

- Introducing explicit fault models

Reasoning with Uncertainty

- Different kinds of uncertainty

- Probabilistic reasoning (Bayes' rule, belief networks)

- Fuzzy logic (characteristic functions, truth-functional approach, rules for combining fuzzy values, defuzzification)

- Dempster-Shafer Theory (uncertainty vs. ignorance, combining evidence, interval view of degrees of belief)

Knowledge Synthesis

The Amphion System

- Automated software synthesis

- Specification acquisition, program synthesis, domain-specific subsystems

- Deductive synthesis approach

Agents and Multiagent Systems

Basics

- Open vs. closed systems

- Definition of agent, properties of intelligent agents

- The autonomy debate, rationality vs. reactiveness (intentional systems, social ability (typology of interaction)

- Definition of multiagent systems

- Research agenda of agent and multiagent systems areas, sub-areas, the programming perspective

Agent Architectures

- Symbolic AI and its problems

- Dispute between behaviour-based and deliberative views of agency

- The BDI architecture (practical reasoning, deliberation and means-ends reasoning, intentions and their properties, issues in BDI)

- Reactive architectures (assumptions, the subsumption architecture, Mars rover example)

- Hybrid architectures (layered approaches, Touring Machines, InteRRaP)

Agent Interaction & Communication

- Categories of agent interaction

- Speech Act Theory (locution, illocution, perlocution, performatives, propositional content)

- Agent Communication Languages (KQML/KIF, FIPA-ACL)

- ACL Semantics (mentalistic semantics, social commitment-based semantics)

- Interaction protocols (protocol design, examples, the contract-net protocol)

Distributed Rational Decision Making

- Decision theory (preferences, expected utility maximisation)

- Game Theory (basics, normal-form games, dominant strategy (equilibrium), best response strategies, Nash Equilibrium, The Prisoner's Dilemma, the evolution of cooperation)

- Mechanism design (criteria: individual rationality, stability, Pareto efficiency, computational efficiency, distribution properties)

- The Revelation Principle (proof!)

- Electronic auctions (English, Dutch/First-Price Sealed Bid, Vickrey Auction, properties of each of them, winner's curse)

- Other methods for distributed rational decision making, critique of game-theoretic approaches

Knowledge Engineering & The Semantic Web

- The Web today, the vision of the Semantic Web

- Semantic Web technologies, the layer cake

- XML, DTDs/XML Schema

- RDF (resources, properties, statements) and RDF Schema (simple lightweight ontologies, semantics)

- OWL (expressiveness, different flavours, shortcomings)

- Critique of the Semantic Web

Knowledge Evolution

Truth Maintenance Systems

- JTMS

- ATMS

Knowledge in Learning

- The knowledge-based inductive learning problem (entailment constraints)

- Explanation-based learning (generalising existing knowledge to cover new situations, procedure, parallel proofs)

- Inductive logic programming (expressiveness, constructive induction, top-down methods, inverse resolution methods, making discoveries with ILP)