WASP- AS2 course Assignment 3

Group 47 – The Hitman

Knowledge representation and reasoning

The Questions

- What is a knowledge base?
- What are the factors that determine which information can be expressed in a given specification language? Give examples.
- What is the cost of having a high expressive specification language? Give examples.
- What is a reasoning process? Give examples of reasoning processes.
- Can learning methods and KRR methods be complemented by each other? If so, give examples.

What is KRR? Examples of Definitions

- Knowledge-representation is the field of artificial intelligence that focuses on designing computer representations that capture information about the world that can be used to solve complex problems [Wikipedia].

- A knowledge representation is most fundamentally a *surrogate*, a substitute for the thing itself, that is used to enable an entity to determine consequences by thinking rather than acting, that is, by reasoning about the world rather than taking action in it [Randall Davis, Howard Shrobe, and Peter Szolovits; *What is Knowledge Representation?*, AI Magazine, 14(1):17-33,1993].

Main Ingredients

- Information encoding (or surrogate)
- Problem solving (or determine consequences by thinking)

- Knowledge representation (or knowledge base)
- Reasoning process

Knowledge Representation (Base)

- Set of known facts about the world (or equivalently the problem)(can be divided in common sense and specialized knowledge),
- A description of the ”connections” between facts.

Example:

In Answer Set Programming facts are represented as boolean predicates: person(Marcus), robot(Yumi) which represent the knowledge that Marcus is a person and Yumi is a robot.

Connections are described as rules: hungry(A) :- running(A) which represent the knowledge that if ”A” went running then it will be hungry.

(Main) Factors about Language Expressivity

- **Consistency**: natural language can be inconsistent, in our everyday life we accept contradiction. For example: ”Johan wants to sit with Sara”, ”Sara wants to sit with Mike”, ”Mike doesn’t want to sit with Johan”, if you want to solve all the constraints the problems is unfeasible. If instead we choose to minimize the number of unsatisfied constraint it will become feasible.
- **Monotonicity**: $\forall A, B, F \;\; if \; A \Longrightarrow F \; then \; (A \wedge B) \Longrightarrow F$. If we add new information to the problem, the previous deductions will still hold. Mathematics satisfies this but not common sense. This in fact is usually not-monotonic (”The Sahara is very hot” is true but if you go there by night it wont be the case).

The Cost of Having a Highly Expressive Specification Language

The relevant properties are two:

- Decidability: can we solve the problem?
- Complexity: can we solve the problem in reasonable time?

Decidability is a theoretical bound while complexity is a practical bound. Undecidable problems (more properly, theories) will not be solved even with infinite time and computational power.

Reasoning Process

The reasoning process is the act of finding implicit knowledge given the explicit knowledge (the facts and rules of the knowledge base).
This can be done in different ways (i.e. different reasoning processes), here some examples from Answer Set Programming:

- Optimization approach: try to maximize some quantity (e.g. number of satisfied facts).
- Cautious reasoning: is some fact always true?
- Brave reasoning: are there cases in which a specific fact is true?
- Incremental solving: start solving a problem and then iterate adding new data.
- …

KRR and Learning

KRR and learning methods are complementary since the former involves the description of the world and ”learn by thinking” paradigm, while the latter implements the ”learn from data” one. Several research effort in this direction are present, both for learning the reasoning process and the knowledge basis [Arvind Ramanathan Neelakantan, *Knowledge Representation and Reasoning with Deep Neural Networks*].

Criticalities arise in how the knowledge representation choices will affect the learning process in terms of: (i)what can or cannot be learned, (ii)speed of learning, (iii)readability of learning outcome [Claude Sammut, *Knowledge Representation Representation Formalisms in Machine Learning*].