Artificial Intelligence Techniques

Knowledge Processing 1

Aims of session
- Introduce types of reasoning
- Deterministic
  - Propositional logic
  - Predicate logic
- Theorem proving

Deterministic
- Aristote (384-322BC)
  - Basic form
  - If-Then
  - First part of rule is either true or false, if true then second part of part activated this can also be true or false.
  - If first part is true then system can initiate an action to make the second part true
  - Deduction-truth of a fact can be deducted from another.

Example ( Taken from Johnson and Picton)
- IF image contains unknown object
  THEN take evasive action
  - The known fact “The image has an unknown object” is true
  - Deduced fact “take evasive action” is true

- George Boole worked out how new statements can be deduced by linking them with AND and OR (connectives).
- Using with the previous example the previous known fact can be split into two facts
  - “image contains an object” is true AND “object cannot be matched in database” is true.
- The known facts have been combined into a single statement which is
  - “image contains an object” AND “object cannot be matched in database” is true.

- Using Boolean logic we can work out the truth of a proposition given the truth values of the sub-propositions.
  - Propositional logic
**Predicate logic**
- Evaluates truth values of compound propositions for the quantifiers
- “for all” (Universal quantifier)
- “there exists” (existential quantifier)

**Dynamic reasoning**
- Logical reasoning does allow functioning when faced with incomplete or inconsistent information to deal with a rapidly changing environment.
- A classic example (taken from Johnson and Picton 1995) “Tweety is a bird” is true and we know “birds fly” is true deduce “Tweety can fly”

**Problem is a new fact is introduced “Tweety is a penguin” is true and “penguins cannot fly” is true, “Tweety can fly” is false.**
- What happened?
- Original deduction was based on two propositions and default knowledge. Deterministic logic assumes no default knowledge so we have a problem.
- Non-monotonic logic allows deduction to change as new evidence arrives, so avoiding needing extra quantifiers.

**Non-deterministic logic**
- Introduce extra logic values such as “unknown”
- Probability

**Proposition and truth**
- $T(X)$ is true if $X$ is true
- $T(X)$ is false if $X$ is false
- $T(X) = T(Y)$
- Why is $T(X) = T(Y)$ not the same as $X = Y$?

**Connectives**
- $X \land Y$ means $X$ AND $Y$
- $X \lor Y$ means $X$ OR $Y$
- $\neg X$ means NOT $X$
- $X \rightarrow Y$ means $X$ implies $Y$ (only false when $X$ is true and $Y$ is false).
Implies

- Taken from Johnson and Picton

- X is inside Y so if Y is false X cannot be true.

Predicate Logic

- In predicate logic we use variables and have quantifiers.

- Proposition in predicate logic are split into a subject (argument) and predicate.

Predicate Logic

- In predicate logic we use variables and have quantifiers.

- Proposition in predicate logic are split into a subject (argument) and predicate.

Quantifiers

- **∀xP(x)**: (universal qualifier) For all x, P(x) is true

- **∃xP(x)**: (existential qualifier) There exists for x such that P(x) is true

Example

- If ( ⋄x on(sensor x))

  Then on(alarm)

  The predicate on(sensor x) is true if sensor x is ON, on(alarm) is true if the alarm is sounding. Therefore there exists a value of x such that the predicate on(sensor x) is true then sound the alarm.

Theorem Proving

- We need a formal system consisting of:
  - Axioms: Propositions that are always TRUE.
  - Rules of inferences
  - Theorems themselves.

  - The goal is show that theorem can be derived from the axioms using the rules of inference only.
Example

- Theorem: It is night.
- We have a sensor that detects the light.

- Propositions:
  - X: sensor is on.
  - Y: it is night.

- Axioms:
  1. Sensor is OFF (¬X)
  2. Sensor OFF (¬X) implies night (Y) (¬X → Y)

- Rules of inference:
  - If (A → B) is TRUE AND A is TRUE then B is TRUE.

Theorem:
- It is Night (Y)

Next week

- Rules of inference
- Uncertainty in reasoning

References