Chapter 18.5
Learning General Logical Descriptions

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Section Outline

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  - G-set/S-set
  - Advantage/Disadvantage

Hypotheses – Basic Concept

- Inductive learning can be viewed as the process of searching the hypothesis space for a good hypothesis.

- A Hypothesis is a logical expression which attempts to classify examples.

- The set of all hypotheses for a learning agent to entertain is its hypothesis space.
Hypotheses – Candidate Definition

- Hypotheses consisted of two components: goal predicate and logical expression (candidate definition).

- Each hypothesis $H_i$ is a sentence of the form
  \[ \forall x \ Q(x) \leftrightarrow C_i \]
  where $C_i$ denotes the candidate definition and $Q$ denotes goal predicate.

Hypotheses - Example

- Example Let $Q$ be WILLWait, We have

  \[ H_r = \forall r \ \text{WillWait}(r) \leftrightarrow \text{Patrons}(r, \text{Some}) \]

  \[
  \begin{align*}
  & \vee \ \text{Patrons}(r, \text{Full}) \ \land \neg \text{Hungry}(r) \ \land \text{Type}(r, \text{French}) \\
  & \vee \ \text{Patrons}(r, \text{Full}) \ \land \neg \text{Hungry}(r) \ \land \text{Type}(r, \text{Thai}) \ \land \text{FriSat}(r) \\
  & \vee \ \text{Patrons}(r, \text{Full}) \ \land \neg \text{Hungry}(r) \ \land \text{Type}(r, \text{Burger})
  \end{align*}
  \]
Hypotheses - Extension

- The hypothesis space (denoted by H) is the set of all hypotheses the learning algorithm can entertain.

- The learning algorithm believes that one of the hypotheses is correct. This notation sentence
  \[ H_1 \lor H_2 \lor H_3 \lor \ldots \lor H_n \]
  considered by learning agent to be true.

- The set of examples which satisfy the candidate definition for a hypothesis is called the extension of that hypothesis.

Examples

- “An example is an object to which the goal concept may or may not apply, and that has some logical description.”

- Description of an example (goshopping) can be presented
  \[ \text{transportation}(x, \text{car}) \land \text{type}(x, \text{mall}) \land \text{products}(x, \text{clothes}) \land \text{goshopping}(x) \]
Examples

- False negative - The hypothesis predicted negative (false) but in fact it is positive (true).

- False positive – The hypothesis predicted positive (true) but in fact it is negative (false).

- To fix inconsistencies such as false negative and false positive, the learning agent must remove the hypotheses that cause inconsistent conclusions from its disjunction of hypotheses.

Current-Best-Hypothesis Search

- “Maintain a single hypothesis, and to adjust it as new examples arrive in order to maintain consistency”

- Generalization - If a false positive is occurs then the extension of the hypothesis must generalizes to include the example.

- Specialization - If a false negative occurs then the extension of the hypothesis must specializes to include the example.
Current-Best-Hypothesis Search

Figure 18.10 (Text book)

(a) A consistent Hypothesis
(b) A false negative
(c) The hypothesis is general
(d) A false positive
(e) The hypothesis is specialized

Current-Best-Hypothesis Search

function CURRENT-BEST-LEARNING(examples) returns a hypothesis

H — any hypothesis consistent with the first example in examples
for each remaining example in examples do
  if c is false positive for H then
    H — choose a specialization of H consistent with examples
  else if c is false negative for H then
    H — choose a generalization of H consistent with examples
  if no consistent specialization/generalization can be found then fail
end
return H

Figure 18.11 (Text Book)

The generalization and specialization are also logical relationships between hypotheses. If Hypothesis H, with definition C₁, is a generalization of hypothesis H, with definition C₁, then we have

∀x C₁(x) ↔ C₂(x)

This is called Dropping Conditions.

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Logic Descriptions
Least-Commitment Search

- Keeps track of all the consistent hypotheses (*version space*) in a hypothesis space is to set bounds on the set hypothesis space.

- Hypothesis Space:
  
  \[ H_1 \lor H_2 \lor H_3 \lor H_4 \lor H_5 \ldots \lor H_n \]

- Eliminates inconsistent hypotheses as examples are examined.

Figure 18.12 (Text Book). Find the subset of V that is consistent with the example

**Version Space:**

- **G-Set** - Set of the most generalized consistent hypotheses
- **S-Set** - Set of the most specialized consistent hypotheses
Least-Commitment Search

- Start: the Version Space = Hypothesis Space
- Initialize S-set equal to all hypotheses that contain just True
- Initialize G-set equal to hypotheses that contain just False

Figure 18.13 Version space contains all hypotheses consistent with the example
Least-Commitment Search

- Terminates Search when
  - There is exactly one hypothesis left
  - Version space collapses (S-Set or G-Set becomes empty)
  - Runs out of examples when there is still more than one consistent hypothesis

Any Question?

Thank You