A (Very) Short Introduction to Description Logics

The following examples illustrate how to use a description logic to represent and reason about types and objects, in particular with the LOOM knowledge representation system.

- **Letters are either vowels or consonants. The vowels are a e i o u y.**

  (defconcept letter
   :exhaustive-partition (vowel consonant))

  (defconcept consonant
   :is letter)

  (defconcept vowel
   :is (and letter
        (one-of a e i o u y)))

  (tellm (vowel a) (vowel e) (vowel i) (vowel o) (vowel u))
  (tellm (letter y) (letter p) (letter n))

  Each individual vowel is defined as an instance. Notice that we defined y as an instance of letter. LOOM uses the definition of vowel and deduces that y is a vowel but p and n are not. It also deduces that a e i o u are all letters as well as vowels.

  Vowels and consonants form what is called an *exhaustive partition* of letter. This means that any letter has to be either a vowel or a consonant, and that no letter can be both.

- **One or more letters form a word. A string can contain letters.**

  (defconcept string
   :is-primitive (at-least 1 has-element))

  (defconcept word
   :is (and string
        (all has-letter letter)
        (at-least 1 has-letter)))

  We can specify additional information about any concept at any time. For example, we may add:

  (defconcept string
   :constraints (at-least 0 has-letter))

  Notice that since some strings are a mix of letters and numbers, having some letter is not part of the definition of string but instead is a constraint. However, it is part of the definition of word.

  (defrelation has-element :domain string)
  (defrelation has-letter :is (and has-element :range letter))
The domain of a relation determines the class of objects for which it can be defined. The range determines the class of objects that can be given as a value (a filler) of the relation. Relations can be defined in terms of other relations, like has-letter.

- Vowel words are a class of words whose letters are vowels. 3-letter words are a class of words that have 3 letters or less.

\[
\text{(defconcept vowel-word :is (:and word (all has-letter vowel)))}
\]

\[
\text{(defconcept 3-letter-word :is (:and word (at-most 3 has-letter)))}
\]

If we now define an instance:

\[
\text{(tellm (:about Spain (has-letter a) (has-letter i) (has-letter p) (has-letter n)))}
\]

Based on the definitions, LOOM will deduce that Spain is not a vowel-word and it is not a 3-letter word. It will also deduce that Spain is a string. LOOM will not deduce that Spain is a word, because it is possible that we specify later that it has an element that is a number. ¹

- Some words are country names.

\[
\text{(defconcept country-name :is-primitive word)}
\]

This concept is defined as primitive, which means that the system will not be given a way to determine when a word is a country name. The user will indicate explicitly which words are country names. Thus, Spain is not considered a country name until we specify so:

\[
\text{(tellm (country-name Spain))}
\]

The following table shows some of the constructors that can be used in LOOM definitions. C and D represent concepts, R represents relations, and k represents a number.

<table>
<thead>
<tr>
<th>Constructor</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>(and C D)</td>
<td>conjunction</td>
</tr>
<tr>
<td>(or C D)</td>
<td>disjunction</td>
</tr>
<tr>
<td>(all R C)</td>
<td>all the values of R are C</td>
</tr>
<tr>
<td>(at-least k R)</td>
<td>R has at least k values</td>
</tr>
<tr>
<td>(at-most k R)</td>
<td>R has at most k values</td>
</tr>
<tr>
<td>(exactly k R)</td>
<td>(at-least k R) and (at-most k R)</td>
</tr>
<tr>
<td>(some R C)</td>
<td>(at-least 1 R)</td>
</tr>
<tr>
<td>(the R C)</td>
<td>(all R C) and (exactly 1 R)</td>
</tr>
</tbody>
</table>

¹For example, we still need to specify \(\text{tellm (:about Spain (has-letter s))}\). In any case, LOOM is able to deduce that Spain is a word once we indicate that we are done with our definitions with \(\text{(set-features :closed-world)}\). See the LOOM manual for more details.