

to the same sc-tuple, the sc-structure will be numbered according to the priority specified below.

- if there are multiple sc-structures connected to sc-tuple that represents universal quantifier or existential quantifier, the sc-structure that only contains variables is numbered preferentially;
- if there are multiple sc-structures connected to the sc-tuple that represents the implication relation, the sc-structure representing the condition is numbered preferentially;
- in the current version, for other situations, the numbering is based on the number of elements contained in the sc-structure. The fewer the number of elements contained in the sc-structure, the numbering will be given priority

Because the atomic predicate formula or the conjunctive formula of the atomic predicate formula is included in the scstructure, once the position of the sc-structure in the semantic graph is determined, the position of each atomic predicate formula in the semantic graph can be determined indirectly. In answer verification, if the standard answer and the user answer are exactly equal, it means that the atomic predicate formulas with the same semantics between the answers have the same position in the semantic graph (That is, the numbering sequence of sc-structure is the same). In the ostis-systems, the atomic predicate formula is expressed using various scconstructions, so this article will establish the mapping relationship of potential equivalent variable sc-node pairs between the answers according to the matching relationship of the sc-constructions in the same position between the answers [4], [8]. The establishment of mapping relationship of the potential equivalent variable sc-node pairs between answers mainly includes the following steps:

- 1) according to the numbering sequence of the sc-structure in the semantic graph, each time a sc-structure pair with the same number is found from the standard answer and the user answer;
- 2) according to the priority order (from high to low) of the various types of sc-constructions used to describe the atomic predicate formula, it is determined in turn whether the current sc-structure pair contains this type of sc-construction at the same time. If the current scstructure pair contains this type of sc-construction at the same time, then, according to the matching relationship of each sc-element between the current sc-construction in the standard answer and the current sc-construction in the user answer, the mapping relationship of the potential equivalent variable sc-node pairs between the current scconstruction pair is established. The priority order of various types of sc-constructions, and the criteria for judging whether the same type of sc-constructions match are as follows:

- because there may be multiple sc-constructions in the same sc-structure, in order to ensure the uniqueness and accuracy of the mapping relationship of the potential equivalent variables sc-node pairs between sc-constructions, this article proposes to establish the mapping relationship between variables sc-nodes according to the priority order of sc-constructions. There are 14 types of sc-constructions in the current version, and the order of priority between them is determined by the number of sc-nodes contained in the sc-construction. The greater the number of scnodes, the higher the priority. If the number of sc-nodes is the same, it is determined according to the number of variable sc-nodes, the greater the number

of variable sc-nodes, the higher the priority;

- the criteria for judging the matching of the same type of sc-constructions are: 1. the constant sc-node at the corresponding position between them exactly matches; 2. there is a mapping relationship between the variable sc-nodes of the corresponding position, or there is no mapping relationship between the corresponding position variable sc-nodes, and there is no mapping relationship between these variables sc-nodes and other variables sc-nodes. If any pair of sc-constructions of the same type in the same position between the answers satisfy the above two conditions at the same time, the mapping relationship between the corresponding position variables sc-nodes between the sc-constructions is established (if there is already a mapping relationship between the two variable sc-nodes, it will not be created repeatedly).

- 3) repeat step 1 — step 2 until all potential equivalent variable sc-node pairs between semantic graphs have established a mapping relationship.

Fig. 3 shows an example of establishing the mapping relationship of potential equivalent variable sc-node pairs between semantic graphs according to the numbering order of scstructures in SCg-code. In Fig. 3, the definition of the inclusion relation is described in the form of a semantic graph ( $\forall A \forall B (A \subseteq B) \iff (\forall a (a \in A \rightarrow a \in B))$ )

When the mapping relationship between the potential equivalent variable sc-node pairs between the semantic graphs is established according to the positions of sc-tuples and scstructures in the semantic graphs, the similarity between the answers can be calculated using formulas (1), (2), and (3). The criteria for judging the matching of substructures are: 1. the constant sc-nodes in the corresponding position between substructures have the same main identifier in the knowledge base or the same number in the semantic graphs (sc-tuple and sc-structure); 2. there is a mapping relationship between the variable sc-nodes at the corresponding position between the substructures.

Next, we will introduce the working algorithm of this scagent in detail:

### Algorithm 3 — The working algorithm of sc-agent for computing semantic similarity of logical knowledge

**Input:** The specific subjective question and the corresponding semantic graph of standard answer and the semantic graph of user answer. The condition of the sc-agent response is that two semantic graphs that use logical knowledge to represent the answer appear in the sc-memory, and the similarity between them has not been calculated.

**Output:** The precision, recall and similarity between answers, and the sc-node used to record the matching status of substructures.

- 1) checking whether all input parameters used for sc-agent work meet the conditions, if so, go to step 2), otherwise, go to step 12);
- 2) checking whether the current question has multiple standard answers, if so, automatically select a standard answer that best matches the user answer according to the approach introduced earlier;
- 3) according to the rules of logical knowledge representation, the semantic graphs of standard answers and user answers are decomposed into substructures;
- 4) the sc-tuples and sc-structures in the semantic graph of the standard answer and the semantic graph of the