Lessons Learned from Ontology Design

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Lessons Learned From Ontology Design (Extended Abstract — Submitted to Protégé 2006)

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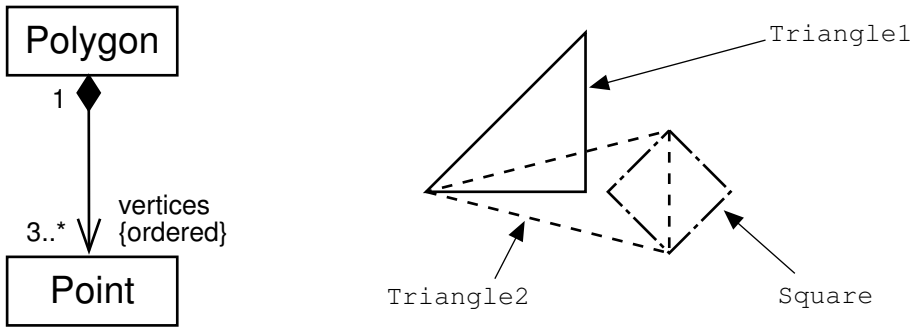
Introduction Since 2001, we are involved in the development of a system named SABRE [1, 2, 3, 4] for supporting the training of military students in the French Army; we expressed the knowledge of the environment and concepts of military work as ontologies using Protégé. We consider that the ontology contains explicit descriptions of the concepts (represented by words: e.g. "to serve one's homeland") used in our military domain. The knowledge is also at stake in the military training and then must be understandable by the students. Finally, not only our ontology must produce usable data structures, but it also must be accepted by the French Army instructors. The SABRE system must consequently possess the necessary data structures so that this knowledge can be edited, filed, recalled, checked with that of the students', stored for future reference, and be used for a training session. However, building ontologies and designing the data structures for such a knowledge-based system are not easy tasks; we recently found that some set-theory-based characteristics extracted from the "under work" ontology could considerably help the ontology builder. This paper describes our experience on building the ontology of the French Military training using Protégé and how this step-by-step process could be supported and guided on-the-fly by systematically checking the theoretical properties of the instance sets of the ontology.

During the design of an ontology for military training [1, 2], we partially solved the ambiguity (getting different interpretations for identical values of different slots), completeness (adding interpretations for all values) and minimality (avoiding intractability) problems with extra design and rules [4]. We here present several (polynomial-time) functions which can automatically detect where to add relevant interpretation rules or complete our ontology (adding classes and slots) for assisting the ontology design.

Illustrative Example This paragraph illustrates the problem we encoutered in the case of ontology design in the domain of military training with the help of a geometrical problem (for the sake of simplicity). Then we present a set of routines which aims at pointing to the classes, slots and instances which are either incomplete or need rules for further interpretation.

On the left of the following figure is an UML class diagram (a) where Polygon and Point are two classes; at least 3 ordered Points can be the vertices of 1 Polygon (adapted from [8, page 68]). (b) is correct with respect to the UML class diagram (a); `Triangle1` and `Square` are instances of Polygon and `Triangle2` is an instance of Polygon whose vertices are made from vertices of `Triangle1` and `Square`. `Triangle1` has vertices {P1,P2,P3}, `Square` has vertices {P4,P5,P6,P7} and `Triangle2` has vertices {P1,P5,P7}:



(a) (b)

May {P1,P5,P7}, instances of Point and vertices of Triangle2, be also vertices Triangle1 and Square? The correctness of drawing (b) with respect to the UML class diagram (a) entails a positive answer to this question[1].

Now consider the following set of coordinates of instances of Point that can be attached to figure (b): $\{(0,0),(0,2),(2,2),(0,3),(0,5)\}$; which of these coordinates are that of the points of Triangle2? It should be obvious that the answer to this question is impossible, providing that many informations are missing (which may not be available), such as the orientation of the axes and the position of their origin.

As illustrated by this geometrical discussion, disambiguization and completeness are the problems we encountered when editing the knowledge of the French Military Training and designing our ontology with Protégé [1]. Our objective is to activate this knowledge so as to educate military staff to the recently designed French soldier's code [5, 6, 7]; the proposed pedagogical method [5] is to confront the learner to a concrete case, describing a real-life military situation where the learner is demanded to act as an actor of the concrete case and play his rôle throughout. In the context of the French Military Training ontology designed from several referential documents [6, 7], the word "discipline" may have different interpretations depending on the articles studied in the current pedagogical training session: for example, in the context of the 10th article of the French Soldier's Code, "discipline" should be interpreted as close as possible as "reserve" (*i.e.*, "secrecy"). But in the 2nd article, "discipline" should be interpreted as close as possible as "courage". The previous question now stands as follows: which of the learner's behaviours activate the articles and themes of the current pedagogical session? To answer this question, we first designed a set of rules to interpret the behaviours along the pedagogical session [2, 3, 4]. However, as we came to discover that some part of our military ontology did not need rules, we came to design a set of functions to automatically detect our need for disambiguization rules (or for enriching our ontology). The next paragraph formally describes these functions.

Towards automatic detection of ambiguities in ontologies? We begin by an analogy with linear algebra, where eigenvalues are the coordinates of the eigenvectors defining the main axes of a vector space (all vectors of a vector space can be written as a combination of these eigenvectors). We thus use the word eigen together with: *(i)* values of a slot of a class, *(ii)* a slot of a class, *(iii)* all instances of a class and finally *(iv)* a class, to denote that the values of the slot of an instance of a class can uniquely determine this instance.

let $\mathcal{V}$ be a set;
let c be a class with a slot s taking as value a subset of $\mathcal{V}$;
let $\mathcal{I}(c)$ be the set of instances of class c;
let $\mathcal{V}(s,i)$ be the set of values of the slot s of the instance i of class c;

[1]Note that object-oriented design answers "no" [8, page 68]: "The general rule is that, although a class may be a component of many other classes, any instance must be a component of only one owner. [...] The "no sharing" rule is the key to composition. Another assumption is that if you delete [a] polygon, it should automatically ensure that any owned Points also are deleted."

function GetEigenValues(s, i):
  let V $\leftarrow \mathcal{V}(s, i)$;
  for all $j \in \mathcal{I}$(GetClass(i)) with $j \neq i$ **do**
    V $\leftarrow$ V $\setminus \mathcal{V}(s, j)$
  end for all;
  return V;

function EigenSlotQ(s, i):
  return (GetEigenValues(s, i)$\neq \emptyset$);

let $\mathcal{S}(c)$ be the set of slots of class c;

function EigenInstanceQ(i):
  for all $s \in \mathcal{S}$(GetClass(i)) **do**
    when EigenSlotQ(s,i) **throw true**
  end for all;
  return false;

function EigenClassQ(c):
  return ($\bigwedge_{i \in \mathcal{I}(c)}$EigenInstanceQ($i$));

When EigenSlotQ(s,i) returns **true**, its EigenValues uniquely determine the instance i; which means, in our case of ontology for military training, that at least one behaviour the learner is asked to play correspond to only one article of the soldier's code or else only one pedagogical theme, thus avoiding the need for interpretation of the behaviour in the context of the article or the theme of the pedagogical session.

When EigenInstanceQ(i) returns **true**, it has at least one EigenSlot, which, in our case of ontology for military training, means that an article has at least one behaviour as unique representative.

Finally, EigenClassQ(c) returns **true** when all its instances have at least one unique representative.

Here is what these functions return in the case of (b):

GetEigenValues(vertices, `Triangle1`)	{P2,P3}
GetEigenValues(vertices, `Triangle2`)	$\emptyset$
GetEigenValues(vertices, `Square`)	{P4,P7}
EigenSlotQ(vertices, `Triangle1`)	true
EigenSlotQ(vertices, `Triangle2`)	false
EigenSlotQ(vertices, `Square`)	true
EigenInstanceQ(`Triangle1`)	true
EigenInstanceQ(`Triangle2`)	false
EigenInstanceQ(`Square`)	true
EigenClassQ(Polygon)	false

As vertices is not an EigenSlot of `Triangle2`, Polygon is not an EigenClass. We either need to add rules to interpret the coordinates correctly, or add at least one slot to Polygon (e.g. barycenter) to distinguish between polygons, or further add classes.

Conclusion The set of functions presented in this paper greatly helped to automatically detect the need to design rules to interpret ambiguous values in our ontology (in the setting of the use of this ontology in a pedagogical session) and ultimately to complete design. These functions run in polynomial time in the number of values of the same slot across all the instances of the same class.

In the final paper, we will describe in details the lessons learned from the design of the French Military Training ontology design and, using the previous functions, formalize the concept of minimality for an ontology that we have been unable to present here due to space limitations.

References

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