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Metalingua, a Formal Language for Metalogic, Semantic Web and Languistics

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Abstract: This paper is an introduction to metalingua to be followed by other papers on its use in linguistics, Semantic Web, and axiomatisation of metalogic. Metalingua is based on a logical symbolism used in my publications and KnowledgeSpace project. Its expressiveness is at least the same as expressiveness of N3 for Semantic Web, but unlike N3, it also satisfies the "compositionality principle" of natural languages, which makes it a tool for the formalisation of languages and development of the natural languages interface for Semantic Web.

Keywords: logic, metalogic, metalingua, semantic web.

1 Introduction

The Leibniz' dream to develop a "universal language" ("lingua characteristica universalis"), resulted in formulation of currently widely used language of predicate logic. But this language is not "universal" enough to describe the language of a theory, and for this purpose logicians have to use metalanguages. It is then natural to require that a universal language serves as a metalanguage for any other languages.

By middle of 20th century, a domain called *metalogic* (see [1]) emerged and preoccupied itself, in particular, with modeling languages by logical methods, but since then no unified language like that of predicate logic was developed for metalogic. In this paper a language called *metalingua* (ML) for formalisation of metalogic is introduced, with a name coming from its relationship with metalogic, its status of metalanguage for other languages, and owing to its "operator *meta*" for the formalisation of metadiscourse.

As per N. Chomsky [2], the future development of linguistics strongly depends on whether a non-classical logic "closer to mind" than classical logic is discovered, a vision called "mentalism". Coincidentally or not, the operations for composing ML expressions appeared in Brain Informatics [3, 4] and in [5], I also explained how ML can serve for interdisciplinarity and transdisciplinarity domains [5].

In Semantic Web (SW), knowledge is expressed in languages defined by standards conceputally based on the “foundational” language “N3”, or “Notation 3”. There is no rigorous proof that N3 can serve as a universal language, and the belief that N3 is universal must be treated as a thesis with same status as Church-Turing thesis. We can show that ML is a universal language, if we manage to map N3 into ML and, thus, show that ML has at least same expressiveness as N3, and this is done in this paper.

N3 is a “relational language” using a 3-ary relationship, but ML is an “operational language” using 3 operations, and, thus, ML satisfies the “compositionality principle”, specific for natural languages stating that the meaning of a compound expression is a function of meanings of operands of the operation whereby the expression was built.

2 Specification of Metalingua

ML has a sublanguage called “Notation A3” from which I will start specifying ML. A3 proceeds from symbols called “atomic expressions” or “atoms”, the set of which is called *vocabulary* of A3 (and of ML). To allow for various vocabularies, we can admit many variants of ML, but in IT it is approapriate to limit to one ML, the atomic expressions of which are strings of Unicode characters. We also say the “symbols” in vocabulary to be *names*, which complies with *common name* versus *proper name* distinction used in linguistics. The expressions of A3 over a vocabulary V are *typed* and are defined by the following recursion rules:

(0) If *a* is a member of V, then *a* is an expression of type *atom*, or “atomic expression”;

(1) If *a* and *b* are expressions, then (a : b) is an expression of type *association* or “association expression”;

(2) If $a_1,..., a_n$ are expressions, then the string $\{a_1,..., a_n\}$ is an expression of type *aggregation*, or “aggregation expression”;

(3) If *a* is an expression, then [*a*] is an expression of type *atom*, or “atomification expression”.

The strange part of this definition is rule (3) which allows that recursion can "invert" the type of a complex expression to atom, a situation which never occurs in other languages. To complete the specification of ML, it should be added that an ML expression is a string of the form ($a = b$) where a and b are expressions of A3.

The notations used in ML have the following origins and justification. An "association expression" is Pierce's notation of ordered pair, which coincides with "qualified name" notation in RDF standard, due to which it can also be called "qualification expression". An "aggregation expression" is a denotation of a finite set, which due to the RDF semantics, can be also called "logical conjuction". Atomification is a new notion, but it reflects the "constituent-structure" vision of Chomsky. I regard an atomification expression as obtained by the operator *meta*, which complies with linguistic practice to refer from the metalanguage to a phrase in the original language by enclosing it between square brackets.

I say the use of ML notations described above to be "denotational use", because the used names serve as *proper names* of the entities they denote. Also I introduce the "discoursive" use, where names which are not denotations are treated as common names in need of interpretation to avoid ambiguity:

(1) (a : b) reads "b is qualified by a", if it occurs standalone, and it reads "*b* qualified by *a*", if it occurs embedded; but for *a* and *b* which are statements, it reads, "*b* implies *a*" or "*a*, implied by *b*";

(2) $\{a_1,..., a_n\}$ reads "a_1 *and* ... *and* a_n", where *and* is logical conjunction, when it is used standalone, and is a generalization of conjunction to any entities with the meaning of *and* in natural languages, when it is embedded;

(3) [a] reads "the a" and has the same meaning as reference to a formal string of characters by including it between quotation marks.

3 Metalingua versus N3

N3 specifies a format for reprezenting information as triples and also has constants which denote a limited number of notions. An N3 triple has the format < *s p o* > of a simple statement, with names *s, p, o,* playing the roles of *subject*, *predicate*, *object*, in the statement read "*s* has the property p with value o". The names used in triples are names. An *ontology* is a set of N3 triples. Formally, from outside of language, we assign a name to an ontology by writing it in front of the text of ontology.

Here is how N3 can be mapped into ML, by putting in correspondence to an ontology named O a ML expression, said to be the *fold* of ontology O:

- Replace a triple $e = <s\ p\ o>$ in O by $((p : s) : o)$, which in ML express the meaning attributed to it by N3, i.e. "o is qualified by the property p of the object s";
- Consider $E = \{e_1,..., e_n\}$, where $e_1,..., e_n$ is the list of triples in O;
- Consider the fold of the ontology named by O as the following ML expression: $(O : E)$.

This is a one-to-one correspondence and, therefore, for each ML expression there is an *unfold* as a N3 ontology.

Metalingua is used in KnowledgeSpace (kspace.info) project to build a system for education and collaboration based on SemanticWeb.

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