~~Thought~~ Synthesis of Semantic Structures

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Particle model for thought synthesis

Property signature

Each property to be added to a V-particle will be administered by P-particle which will be consumed by the acceptor V-particle. Each P-particle has unique signature which becomes signature of the corresponding property and will be embedded into the V-particle signature.

Particle Signature

A fixed $N_S \times N_S$ bit matrix where the number of bits N_S is large enough will identify uniquely all distinct particles. In case V is a compound particle some properties of the composing sub-particles may be identified from the signature. Possible values for N_S are: 512 resulting in 4KB signature and 1024 resulting in 16KB signature. Represented by a binary blob of size $\frac{{N_S}^2}{65536}$KB with sequentially ordered rows in increasing order.

Association Particles

The Association Particles a.k.a. as A-particles fulfill multiple roles:

- Manage the addition and removal of properties to the compound particle altering the semantics of the compound thought.
- Identify and attract matching particles in the synthesis of new semantic structures
- Transform the compound particle signature such that a subset of properties of the compound particle will be preserved in the signature. This will render possible the comparison and semantic distance evaluation among close semantically particles. This transformation impacts both signature and the semantic tree of the particle hence may alter the result of any of the operations performed on the particle.

Note: the state of the A-particle instance which will be associated with two V-particles will depend on the context, on the particle signatures and on the semantical construct in which those particles appear. A-particle may alter the signatures of the surrounding V-particles thereby adding new properties pertaining to the compound particle.
The following notation with respect to the association particles of a compound particle V_{comp} is adopted:
$V_{comp} = [\, V_1\, A_1\, V_2\, A_2\ \dots\ A_{k-1}\, V_k\, A_k \,]$
Here A_i , $1 \le i < k$ is an association particle which binds its neighbors $[V_1 A_1 \dots A_{i-1} V_{i-1}]$ and V_{i+1}.
The last association particle in red depicts the association particle which pertains to the whole compound V_{comp} ; all properties which are related to the compound are added to A_k. Usually A_k is omitted when denoting compound particles as it is implicitly defined for every compound particle.

Semantic graph

Thoughts which are related will be represented by semantic graph.

Semantic tree

Each V-particle or a thought can be represented by a semantic tree of sub-particles
Operations on semantic trees:

- semantic operations: *is_part_of(another_thought), infer(another_thought), relate(another_tree), compare(another_thought, max_dist)*

- data structure operations: *extract(root_of_subtree, exclude(subtree), exclude(list_of_nodes), merge(another_tree), is_subtree(root_of_tree), include(list_of_nodes)*

Construction of semantic tree of a thought or compound particle

Let us have the compound particle V_{comp}

$V_{comp} = [\, V_1\, A_1\, V_2\, A_2\, \ldots\, A_{k-1}\, V_k\, A_k \,]$

The topology of the semantic tree is recovered from information stored in the A-particles while the nodes of the tree are V-particles of V_{comp}. The semantic tree represents a normalized form of the recorded in V_{comp} semantic structure and facilitate various operations between semantic structures. The semantic tree also reveals the normalized syntactic structure of V_{comp}. The normalized syntactic structure is obtained either as a dependency grammar (DG) tree or as a phase-structure grammar (PSG) tree.

Construction of the semantic tree of this compound particle occurs by starting with A_k which will contain markers of the V-particle(s) at the 1st level. After the 1st level has been constructed for each V-particle on this level the two neighbor A-particles are inspected and based on the stored in them information it is decided which will be the next node of the semantic tree.

Example 1:

Dimitar and Mieko are riding in the car.

```
               ________riding___
             /              |         \
   Dimitar                are        in
      /      \                      /  \
and       Mieko                   the   car
```

Example 2:

Karl had immediately recognized Maria when she got off the bus.

```
          _________recognized____________________________
        /                    |           |            \              \
     Karl                  had     immediately     Maria          when
                                                                    \
                                                                    she
                                                                      \
                                                                      got
                                                                     /   \
                                                                   off   bus
                                                                          /
                                                                        the
```

Note: In these two examples it is shown the dependency tree (*stemma*[1]) corresponding to each of them.

[1] For details see (Tesniere, 2015)

Rules of Inference

Let us consider the compound semantic structure represented by the text "*Dimitar's book*". We immediately recognize three V-particles in this structure:

V_1 with $text(V_1)$ = "*Dimitar*"
V_2 with $text(V_2)$ = "*'s*"
V_3 with $text(V_3)$ = "*book*"

There is a single enclosing context and there is a single thought in it:
Dimitar is staying at home now. His house is located in Hudson, Massachusetts.

The following V-particles are defined in the global context (GC):

V_{gl1} with $text(V_{gl1})$=*"book"*
V_{gl2} with $text(V_{gl2})$=*"paper"*
V_{gl3} with $text(V_{gl3})$=*"wood"*
V_{gl4} with $text(V_{gl4})$=*"rectangle"*
V_{gl5} with $text(V_{gl5})$=*"page"*
V_{gl6} with $text(V_{gl6})$=*"letters"*
V_{gl7} with $text(V_{gl7})$=*"has"*
V_{gl8} with $text(V_{gl8})$=*"is"*
V_{gl9} with $text(V_{gl9})$=*"indicates"*
V_{gl10} with $text(V_{gl10})$=*"made of"*
V_{gl11} with $text(V_{gl11})$=*"owner of"*
V_{gl12} with $text(V_{gl12})$=*"ownership"*
V_{gl13} with $text(V_{gl13})$=*"shape of"*

The following thoughts are recorded in GC:

$[V_{gl1}\ A\ V_{gl8}\ A\ V_{gl10}\ A\ V_{gl2}]$ -> *"book is made of paper"*
$[V_{gl2}\ A\ V_{gl8}\ A\ V_{gl10}\ A\ V_{gl3}]$ -> *"paper is made of wood"*
$[V_{gl1}\ A\ V_{gl7}\ A\ V_{gl13}\ A\ V_{gl4}]$ -> *"book has shape of rectangle"*
$[V_{gl1}\ A\ V_{gl8}\ A\ V_{gl10}\ A\ V_{gl5}]$ -> *"book is made of pages"*

General Form for the Rules of inference for a sequence of thoughts $\mathfrak{S}_T$

Let us denote by $\mathfrak{S}_T$ a thought sequence composed of thoughts from a set of contexts $\mathfrak{C}$ on the same context path. Let us denote with $T_1, T_2, \ldots, T_k$ the thoughts in $\mathfrak{S}_T$. Let us denote by $\mathfrak{T}_V$ a set of V-particles which are entirely contained in the thought sequence $\mathfrak{S}_T$ such that each of the thoughts in $\mathfrak{S}_T$ contains at least one V-particle from $\mathfrak{T}_V$. The set $\mathfrak{T}_V$ will be the *inference trigger* which if present will kick start the synthesis of a new sequence of thoughts $N_1, N_2, \ldots, N_l$ which will be the result of the inference. The new ordered sequence of thoughts will be denoted with $\mathfrak{S}_N$. The mapping from $\mathfrak{S}_T$ to $\mathfrak{S}_N$ will represent inference operation which will be triggered by the presence of $\mathfrak{T}_V$.

$$\mathfrak{S}_T(\mathfrak{C}) \xrightarrow{\mathfrak{T}_V} \mathfrak{S}_N(\mathfrak{C})$$

Learning of new Rules of inference

During the phase of parsing new thoughts or in thought analysis phase new rules of inference may be created or existing ones modified. This may happen when the new chain of thoughts are ranked higher or equal to the minimum rank of the existing rules of inference.

//TODO: Finish this

Recombination Particles and Conservation Laws

//TODO: Finish this

Affinities and Affinity Sets

Let us consider a particle denoted by V_1. Let us consider the case when the particle V_1 combines from the right with another compound particle V_a as shown below

$V_a - A_a - V_1$

The affinity for each of the two V-particles gets calculated and information about the affinity value gets recorded inside the A-particle which is intermediary for the two V-particles. In this case the intermediary is A_a which stores information on chosen combination $[V_a A_a V_1]$. Any new attempt to recombine the particle V_1 with another compound particle will involve A-particle clone of A_a. This A_a clone already has learned V_1's affinity for V_a and will encourage recombining V_1 with such V-particles which have close enough semantic distances to V_a.

Now, let us consider the compound particle $[V_1 A_1 V_2]$. This particle has been initially combined with another compound particle V_b where V_b is not close to V_a semantically.

Example: Let us consider the compound particle *"Dimitar's book"*, represented by $[V_1 A_1 V_2 A_2 V_3 A_3]$.

Here:

$V_1 = \text{"}Dimitar\text{"}$

$V_2 = \text{"'}s\text{"}$

$V_3 = \text{"}book\text{"}$

$A_{left} - [V_1 A_1 V_2 A_2 V_3] - A_{right}$

$|\_\_\_A_3\_\_|$

Bibliography

Tesniere, L. (2015). *Elements of Structural Syntax.* Amsterdam / Philadelphia: John Benjamins Publishing Company.