On The Semantic Significance of an Association and Particles

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The Semantic Significance Vector

Notation

P denotes semantic property
V denotes primitive semantic particle
S denotes semantic structure / composite semantic particle
S^+ denotes semantic structure with outbound association links
S^- denotes semantic structure with inbound association links
$S^\pm$ denotes semantic structure with outbound and inbound association links
AS^+ denotes outbound association link
AS^- denotes inbound association link

$\mathbf{w}_j(P)$ semantic significance vector of semantic property
$\mathbf{w}_j(V)$ semantic significance vector of primitive semantic particle
$\mathbf{w}_j(S)$ semantic significance vector of semantic structure
$\mathbf{w}_j(S^+)$ semantic significance vector of semantic structure with outbound association links
$\mathbf{w}_j(S^-)$ semantic significance vector of semantic structure with inbound association links
$\mathbf{w}_j(S^\pm)$ semantic significance vector of semantic structure with outbound ***and*** inbound association links
$\mathbf{w}_j(AS^+)$ semantic significance vector of outbound association link
$\mathbf{w}_j(AS^-)$ semantic significance vector of outbound association link

Purpose of Semantic Significance vector

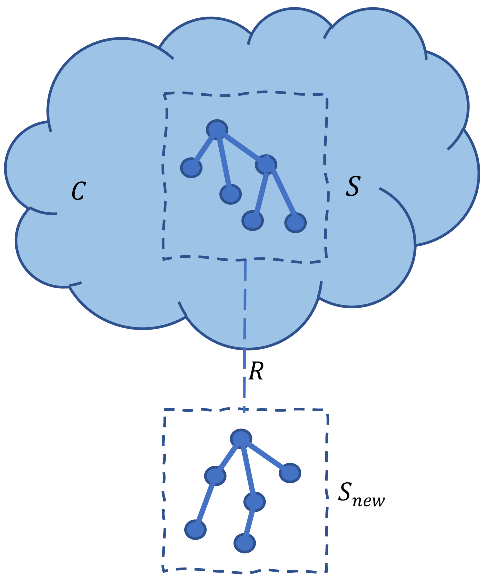
The semantic significance vector will be used in a reinforcement-learning mechanism used to rank semantic structures (thoughts) by relevance with respect to a given context. Thus when making inferences we will be able to choose the most relevant (semantically significant) inferred structure based on previously parsed and stored semantic structures (thoughts).

Inequalities which the semantic significance vector and its components obey

The absolute value of the semantic significance vector is always a positive real number which is smaller or at most equal to 1:
$0 < |\mathbf{w}| \leq 1$

The value of each component of the semantic significance vector is in the range $(0, 1]$.
We have $\mathbf{w} = \sum_{j=1}^{J} w^j \mathbf{e}_j$
Then $0 < w^j \leq 1$.

How do we ascribe a semantic significance of the relation R of a given semantic structure S_{new} with another semantic structure S_2 part of the current context C?
In order to answer this question let us consider the following cases



Semantic Significance of a primitive semantic particle

Recall that the properties of primitive semantic particles are organized in a property tree:

V_1 $\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ V_2 \`

P_1 P_2 P_3 $\qquad\qquad\qquad\qquad\qquad\qquad$ P_1--- o --- P_2
\ | / .. $\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ / | \
P_k --- o --- P_i $\qquad\qquad\qquad\qquad\qquad\qquad$ P_3 P_4 P_5_
.. / | \ .. $\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ / \ | \
P_{j+1} P_j P_{j-1} $\qquad\qquad\qquad\qquad\qquad$ P_6 P_7 P_8 P_9
$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ |
$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ P_{10}

We can assign a semantic significance vector $\mathbf{w}_j(V)$ for each property $P_j(V)$ and its parent $par\left(P_j, V\right)$.

____
__________| |____
| $\mathbf{w}_j$ |_____
| $par\left(P_j\right)$ --------- P_j V _|
|__ ____________________|
|________|

Following the semantic tree notation (for details see Semantic Tree Operations) for property tree of the particle V_1 below

V_1

```
      P1
    /    \
  P2       P3
          / | \
        P4  P5  P6
```

$prop\_tree(V_1) = (w_0, P_1) + (w_0 w_1, P_2) + \big(w_0 w_2, \; \big((1, P_3) + (w_3, P_4) + (w_4, P_5) + (w_5, P_6)\big)\big)$
This is expanded to:
which is expanded to:
$prop\_tree(V_1) = (w_0, P_1) + (w_0 w_1, P_2) + (w_0 w_2, P_3) + (w_0 w_2 w_3, P_4) + (w_0 w_2 w_4, P_5) + (w_0 w_2 w_5, P_6)$
From the last relation we can compute the adjusted semantic significance for the particle V_1 as
$$w(V_1) = w_0 + w_0 w_1 + w_0 w_2 + w_0 w_2 w_3 + w_0 w_2 w_4 + w_0 w_2 w_5 \qquad (1)$$
Note that all w's in the last equation denote scalar quantities and correspond to one specific dimension in the semantic significance vector space. After applying (1) for each dimension we obtain the semantic significance vector of the particle V_1:

$$\mathbf{w}(V_1) = \sum_{j=1}^{J} \left(w_0^j + w_0^j w_1^j + w_0^j w_2^j + w_0^j w_2^j w_3^j + w_0^j w_2^j w_4^j + w_0^j w_2^j w_5^j\right)\mathbf{e}_j \qquad (2)$$

Here $\mathbf{e}_j, j = 1..J$ are the unit vectors for the dimensions of the semantic significance space.

Semantic significance of composite semantic particle

Let us consider the simplest possible composite semantic particle which is constructed from two primitive particles V_1 and V_2 connected by the association particle A with semantic significance vector $\mathbf{w}$.

```
         _____  Vc
      __|     |__
   __|     A     |__
  |    V1 --- V2    |
  |__      w      __|
     |__       __|
        |_____|
```

Let us denote by I_1 and I_2 the number of properties in V_1 and V_2 accordingly. Hence $|prop\_set(V_1)| = I_1$ and $|prop\_set(V_2)| = I_2$.
Based on our analysis in the previous section we can rewrite (2) in a more general form:
$$\mathbf{w}(V_2) = \sum_{j=1}^{J} P_2\left(w_0^j, w_1^j, \dots, w_{I_2}^j\right)\mathbf{e}_j \qquad (3)$$
where $P_2\left(w_0^j, w_1^j, \dots, w_{I_2}^j\right)$ is some polynomial with respect to the scalar semantic significance values corresponding to each property on the property tree of V_2. Note that the scalar values $w_1^j, \dots, w_{I_2}^j$ can indeed be matched to specific properties on the property tree of V_2 but w_0^j cannot. Indeed w_0^j has free running value for all semantic significance dimensions and if we are calculating the semantic significance of the particle V_2 in isolation we simply set $w_0^j = 1 \; \forall \, j = 1..J$. However, if V_2 is connected to another particle via the association A with its own semantic significance $\mathbf{w}(A)$ then we can reduce the semantic

significance of the structure $A^* = A - V_2$ to a new adjusted vector $\mathbf{w}(A^*) = \mathbf{w}(A - V_2) = \sum_{j=1}^{J} P_2\left(w^j, w_1^j, \dots, w_{I_2}^j\right)\mathbf{e}_j$ where $\mathbf{w}(A) = \sum_{j=1}^{J} w^j \mathbf{e}_j$. Then

$$\mathbf{w}(V_c) = \mathbf{w}(V_1 - A - V_2) = \sum_{i=1}^{J} P_1\left(w_0^i, w_1^i, \dots, w_{I_1}^i\right)\mathbf{e}_i - \sum_{j=1}^{J} w_0^j P_2\left(w^j, w_1^j, \dots, w_{I_2}^j\right)\mathbf{e}_j \quad (4)$$

The vector $\mathbf{w}(V_c)$ represents the semantic significance vector of the compound particle V_c.
Note that each scalar value of $w_j(V_c)$ is polynomial of $I_1 + I_2 + 2$ parameters $w_0^j, w_1^j, \dots, w_{I_1}^j, w^j, w_1^j, \dots, w_{I_2}^j$ one of which , w_0^j, is a free parameter and if we calculate the semantic significance of particle V_c in isolation we set $w_0^j = 1 \; \forall \, j = 1..J$.

Semantic significance of a semantic structure with inbound is-a relations

Let us assume that R represents inbound *is-a* relation for S_{new}. That is, R is a *is-a* association between a particle V_{new} in S_{new} and S in C. First, let us identify which are the factors which influence the significance of the inbound *is-a* link. Let us denote by $\mathcal{W}_S$ the set of semantic significance vectors in S. Similarly, by $\mathcal{W}_{S_1}, \dots, \mathcal{W}_{S_k}$ we denote the set of the semantic significance vectors in $S_1, \dots, S_k$.
Let us denote by $A^1, A^2, \dots, A^I$ the set of all A particles which belong to structure S. Accordingly, by $\mathbf{w}^1, \mathbf{w}^2, \dots, \mathbf{w}^I$ we denote the semantic significance vectors for those A particles in S. Let denote the number of scalar components in each $\mathbf{w}^i$ by J. Hence J represents the number of semantic significance dimensions in S i.e. $J = \dim \mathbf{w}^i$.
Then one can define the following vector:

$$\mathbf{w}_S^{min} = \left[\min_i w_1^i, \min_i w_2^i, \dots, \min_i w_J^i\right]$$

Thus, for each semantic significance dimension we select the minimal scalar value from the set of semantic significance vectors which pertain to S.

Let us assume that there are k inbound *is-a* associations to S - $R_1, R_2, \dots, R_k$ linking $V_1, V_2, \dots, V_k$ in S with $S_1, S_2, \dots, S_k$ in C. How would we rank them and assign semantic significance vector to each of those *is-a* relations? How would the semantic significance vectors of the relations $R_1, \dots, R_k$ impact the semantic significance vector of R? Let us denote with $\mathbf{w}_{R_1}, \dots, \mathbf{w}_{R_k}$ the semantic significance vectors of $R_1, \dots, R_k$. Let us denote with $\mathbf{w}_1, \dots, \mathbf{w}_k$ the semantic significance vectors of the A particles connecting $V_1, \dots, V_k$ with their parents in S:

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                         _______________
                ______|                 |__________
          _____|                S                  |___________
   ______|                                                     |_____
  |                                                                  |____
  |        w_1               w_2                        w_k               |__
  |   P(V_1) ----> V_1    P(V_2) ----> V_2      ...     P(V_k) ----> V_k    _|
  |______________________________________________________________________|
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