

## 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

$w_j(P)$  semantic significance vector of semantic property

$w_j(V)$  semantic significance vector of primitive semantic particle

$w_j(S)$  semantic significance vector of semantic structure

$w_j(S^+)$  semantic significance vector of semantic structure with outbound association links

$w_j(S^-)$  semantic significance vector of semantic structure with inbound association links

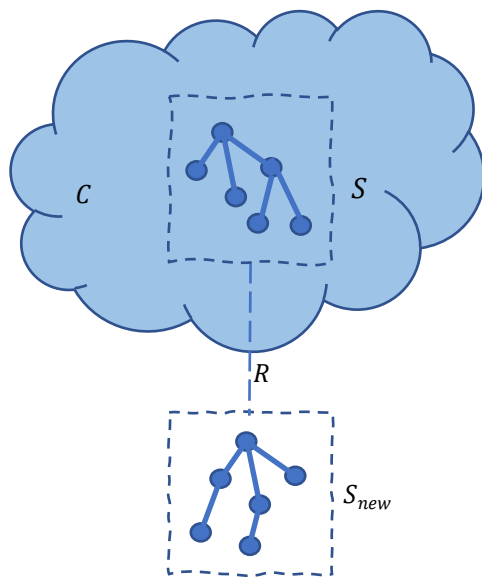
$w_j(S^\pm)$  semantic significance vector of semantic structure with outbound **and** inbound association links

$w_j(AS^+)$  semantic significance vector of outbound association link

$w_j(AS^-)$  semantic significance vector of inbound association link

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

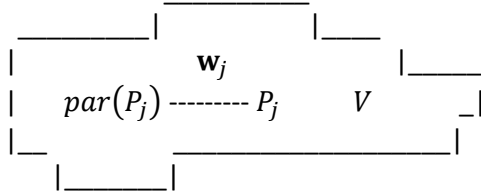


## Semantic Significance of a primitive semantic particle

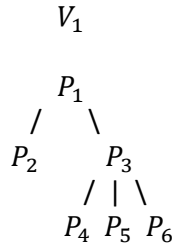
Recall that the properties of primitive semantic particles are organized in a property tree:



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



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



$$prop\_tree(V_1) = (w_0, P_1) + (w_0 w_1, P_2) + (w_0 w_2, ((1, P_3) + (w_3, P_4) + (w_4, P_5) + (w_5, P_6)))$$

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

$$w(V_1) = w_0 + w_0 w_1 + w_0 w_2 + w_0 w_2 w_3 + w_0 w_2 w_4 + w_0 w_2 w_5 \quad (1)$$

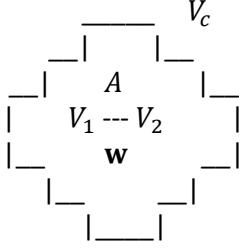
Note that all  $w$ 's in the last equation denote scalar quantities and correspond to one specific dimension in the semantic significance vector space. After applying [\(1\)](#) for each dimension we obtain the semantic significance vector of the particle  $V_1$ :

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

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  $\mathbf{w}$ .



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:

$$\mathbf{w}(V_2) = \sum_{j=1}^J P_2(w_0^j, w_1^j, \dots, w_{I_2}^j) \mathbf{e}_j \quad (3)$$

where  $P_2(w_0^j, w_1^j, \dots, w_{I_2}^j)$  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  $\mathbf{w}(A^*) = \mathbf{w}(A - V_2) =$

$\sum_{j=1}^J P_2(w^j, w_1^j, \dots, w_{I_2}^j) \mathbf{e}_j$  where  $\mathbf{w}(A) = \sum_{j=1}^J w^j \mathbf{e}_j$ . Then

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

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 by  $\mathcal{W}_S$  we denote 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:

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

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  $S$ :

