

Note on binding of an association particle to semantic particles

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Primitive semantic particles

Let us consider two primitive semantic particles - V_i and V_j connected through association particle (link) $A_{i,j}$.

$$V_i \text{---} A_{i,j} \text{---} V_j$$

The particles V_i and V_j are represented by their semantic signatures \mathbf{V}_i and \mathbf{V}_j . The association link $A_{i,j}$ is represented with its association matrix $\mathbf{A}_{i,j}$ and semantic significance vector $\mathbf{W}_{i,j}$.

The association matrix $\mathbf{A}_{i,j}$ captures the affinity force $F(V_i, V_j, t)$ between the particles V_i and V_j at the time t of constructing the compound structure involving those particles. Note that the magnitude of affinity force between the particles may change as their semantic positions and signatures are altered in the future. A change in the affinity force $F(V_i, V_j, t + \Delta t)$ at a future moment $t + \Delta t$ may change the matrix $\mathbf{A}_{i,j}$ of the association link between the altered particles. Altering the semantic position of a particle will require reevaluating the semantic links of this particle with the relevant enclosing contexts.

The association matrix has the following structure:

$\mathbf{A}_{i,j} = [\mathbf{a}_{p_1, q_1} \dots \mathbf{a}_{p_m, q_n}]$ where the pairs p, q denote all relevant property pairs where the left property belongs to V_i and the right property belongs to V_j . Let us denote with \mathcal{P} the set of property indices which belong to V_i and with \mathcal{Q} the set of indices which belong to V_j . Then $p \in \mathcal{P}$ and $q \in \mathcal{Q}$. Note that the map $\mathcal{P} \rightarrow \mathcal{Q}$ is many-to-many. That is, the same index p may appear multiple times with different $q \in \mathcal{Q}$ and the same index q may appear multiple times with different $p \in \mathcal{P}$. The property association matrices $\mathbf{a}_{p,q}$ have the following structure:

$$\mathbf{a}_{p,q} = \begin{bmatrix} \mathbf{r}_1^p & \mathbf{r}_1^q \\ \mathbf{0} & \mathbf{0} \\ \mathbf{r}_2^p & \mathbf{r}_2^q \\ \mathbf{0} & \mathbf{0} \\ \vdots & \vdots \\ \mathbf{0} & \mathbf{0} \\ \mathbf{r}_k^p & \mathbf{r}_l^q \end{bmatrix}$$

So $\mathbf{a}_{p,q}$ is a two-column matrix of size $N \times 2$ with non-zero regions in each column denoted by the vectors \mathbf{r}_i^p where $\sum_{i=1}^k \text{size}(\mathbf{r}_{i=1}^p) \leq N$ and $\sum_{j=1}^l \text{size}(\mathbf{r}_j^q) \leq N$. The non-zero regions \mathbf{r}_i^p and \mathbf{r}_j^q are also known as the **active regions** of the association link between the two properties $P_p \in ptree(V_i)$ and $P_q \in ptree(V_j)$ at time t . For details refer to [Note On Binding Of An Association Property to Semantic Properties](#).

The binding force between the two V -particles is conveyed through the Association Particle which exposes the active regions which are to be considered. The binding force is given with the expression:

$$F^b(V_i, V_j | A_{i,j}) = \sum_{P_k \in \{V_i \cap A_{i,j}\}, P_l \in \{V_j \cap A_{i,j}\}} \sum_{a \in P_k, b \in P_l} f(\mathbf{r}_a^k, \mathbf{r}_b^l)$$

Here f denotes the binding force between a pair of property regions. The set $\{V_i \cap A_{i,j}\}$ denotes all properties of V_i which are included in $\mathbf{A}_{i,j}$. Similarly, the set $\{V_j \cap A_{i,j}\}$ denotes all properties of V_j which

are included in $\mathbf{A}_{i,j}$. The notation $V_i, V_j | A_{i,j}$ reflects the fact that the property pairs contributing to the total binding force is filtered by the chosen in $\mathbf{A}_{i,j}$ property pairs.

In other words, the Association Particle is acting as a filter which selects which property pairs are relevant and will contribute to the binding force between V_i and V_j .

Obviously $F^b(V_i, V_j | A_{i,j})$ will be smaller or equal than the binding force $F^b(V_i, V_j)$ created by considering all property pairs without an Association Particle acting as a mediator and a filter:

$F^b(V_i, V_j | A_{i,j}) \leq F^b(V_i, V_j)$ where $F^b(V_i, V_j)$ is given as

$$F^b(V_i, V_j) = \sum_{P_k \in \{V_i\}, P_l \in \{V_j\}} \sum_{a \in P_k, b \in P_l} f(\mathbf{r}_a^k, \mathbf{r}_b^l)$$

Accounting for Semantic Significance vector when calculating binding force between two semantic particles

The Semantic significance vector \mathbf{w} of the association between two V-particles does not impact the binding force between the particles. The Semantic Significance is a mechanism for selecting the most semantically significant thought (semantic structure) under specific circumstances from a set of candidates and this concern is orthogonal to the integrity of the semantic structures.