Particle Approach for creating Physics-based Semantic Algorithms

Types of particles

V-particle: *semantic particle* or *node particle* – smallest unit of semantic information. Represent the nodes in the DAG of a semantic structure.
N-particle: *naked particle* - special kind of V-particle which contains only single property – $text$ and is connected to other naked particles through A-particles.
A-particle: *connection particle* or *association particle*, carrier of the attraction force between two (possibly naked) V-particles. Represents the arcs in the DAG of a semantic structure.
P-particle: property particle, carrier of the properties of the V-particles

M-particle: *mass particle* – carrier of the mass of a V-particle or a semantic structure
Q-particle: *charge particle* carries the charge of a V-particle which determines if a pair of V-particles will repel or attract each other and by what “force”.

R-particle: *rank particle* - used to determine the relative order of a structure
T-particle: *time particle* – contains a time marker which is a measure of the longevity of a given semantic particle. As soon as T-particle attaches to a semantic particle it cannot be split or decay for the lifespan of that semantic particle that is until that semantic particle splits or decay.

E-particle: *execution particle* – executes an operation when attached to a V-particle
D-particles: *director particle* – a special type of E-particle. Directs the execution to the attached to it E-particles. Serves as a switch which routes the execution to the relevant execution tree branch.

Laws governing the creation, merging, splitting and decay of particles

Laws of repulsion and attraction
Particles with opposite charges attract each other. Particles with the same charge sign repel each other.

Particle eviction with replacement: it occurs when a particle with similar enough signature to the one being evicted is found in an outer context if the first is attracted stronger to the nearby particles than the one which is being evicted.

Particle eviction without replacement: it occurs when a charge of a particle is altered such that the “force” binding the particle to its neighbors changes sign from attractive to replacement.

The idea is to maximize the attraction force in a semantic structure through binding and eviction of particles to it. We should be guided by the structural charges and generated forces. A set of particles with total charge close enough to zero becomes an *independent thought*.

Example:
John is the father of Sam. Julie is the mother of Sam. If a person is your father and another person is your mother then you are their son.

V-particles are rearranged together with A-particles into a DAG via the laws of repulsion and attraction

Conservation laws
Are such laws applicable in Semantic space and if yes under what settings?
Conservation of mass
Conservation of charge
Conservation of color
Conservation of energy
Conservation of momentum

Process for dressing naked particles

$$
\begin{tikzcd}[arrows=dash]
 & N \arrow[d] & & \\
MR_1 \arrow[r, dashed] & text \arrow[rr, dashed] \arrow[dl] \arrow[d] \arrow[drr] & & MR_l \\
MA_1 \arrow[d] & MA_2 \arrow[d] & \dots & MA_k \arrow[d] \\
AS_1 \arrow[d] & AS_2 \arrow[d] & \dots & AS_k \arrow[d] \\
MA^1 \arrow[d] & MA^2 \arrow[d] & \dots & MA^k \arrow[d] \\
text_1 \arrow[d] & text_2 \arrow[d] & \dots & text_k \arrow[d] \\
V_1 & V_2 & \dots & V_k
\end{tikzcd}
$$

MA – match-seeking particle
MR – match-repelling particle – acts as a repellent toward particular association particles. Models constraints imposed on certain V-particles in terms of similarity matching
AS – similarity particle: a special type of link particle (A-particle)
N – naked particle candidate for dressing
$text$ – the text property value of the naked particle N
V_i – V-particle (semantic particle)

When do we terminate the particle chain established by similarity association?
Consider a set of k V-particles semantically close to each other: $V_1, V_2, \dots, V_k$
Let us assume that we have established a viable association between a pair from the set:

$$\exists\, i, j \in [1, \dots, k] \quad V_i \text{ --- } MA_i \text{ --- } A_i \text{ --- } MA^j \text{ --- } V_j$$

Let us assume we have a set of pairs for which association link can be established:

$$(i_1, j_1), (i_2, j_2), \dots, (i_l, j_l),\ l = 1..k^2$$

Let us consider the first matched tuple (i_1, j_1)

N
|
$text$
/ \
MA_{i_1} MA_{j_1}
/ \
/ \
/ \
/ \
AS_{i_1} AS_{j_1}
/ \
/ \
/ \
/ L_{i_1,j_1} \
MA^{i_1} MA^{j_1}
/ \
$text_{i_1}$ $text_{j_1}$
/ \
V_{i_1} —- $MA_{(V_{i_1})}$—$AS_{(i_1,j_1)}$—-$MA_{(V_{j_1})}$—- V_{j_1}

The loop N-MA_{i_1}-AS_{i_1}-MA^{j_1}-V_{i_1}-$MA_{(V_{i_1})}$-$AS_{(i_1,j_1)}$-$MA_{(V_{j_1})}$-V_{j_1}-MA^{j_1}- AS_{j_1}-MA_{j_1}- N will be denoted with L_{i_1,j_1}.

Coulomb's law for semantic particles

Let the particle V_{p_1} has "charge" with value q_1 and particle V_{p_2} has property "charge" with value q_2. Then if $sign(q_1) \neq sign(q_2)$ there will be attraction force between the two particles with magnitude F:

$F(V_{p_1}, V_{p_2}) = K \times \frac{|q_1| \cdot |q_2|}{f(r)}$ where $K > 0$ is some proportionality constant and $f(r)$ is some monotonously increasing function of the semantic distance $r(V_{p_1}, V_{p_2})$ between the two particles. If $sign(q_1) = sign(q_2)$ the force would be repelling and will be with the same magnitude F.

The binding force F^b of the association loop L_{i_1,j_1} is given with:

$$F^b(L_{i_1,j_1}) = F(MA_{i_1}, AS_{i_1}) + F(MA^{i_1}, AS_{i_1}) + F\left(MA_{(V_{i_1})}, AS_{(i_1,j_1)}\right) + F\left(MA_{(V_{j_1})}, AS_{(i_1,j_1)}\right) + F(MA_{j_1}, AS_{j_1}) + F(MA^{j_1}, AS_{j_1})$$

Here the attraction force between the match seeing particle MA and the similarity particle AS is given with the Coulomb's law for semantic particles.