

## Particle Approach for creating Physics-based Semantic Algorithms

D. Gueorguiev 8/21/21

Introduces a mechanistic approach for modeling of semantic processes and structures where certain ideas and concepts have some degree of similarity with concepts from modern Physics. The rationale for such approach is that the thought processes are governed by evolutionary (adaptive) state machine which can be understood and modeled borrowing ideas from modern Physics.

### Types of particles

Semantic 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: *raw (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 raw) *V*-particles. Represents the arcs in the DAG of a semantic structure. Does carry additional semantic information.

*P*-particle: property particle, carrier of the properties of the *V*-particles, does not have a semantic meaning on its own, does not carry semantic information on its own.

Physical 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”.

Marking particles

*R*-particle: *rank particle* - used to determine the relative order of a structure

*T*-particle: *timestamp 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.

Executive particles

*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

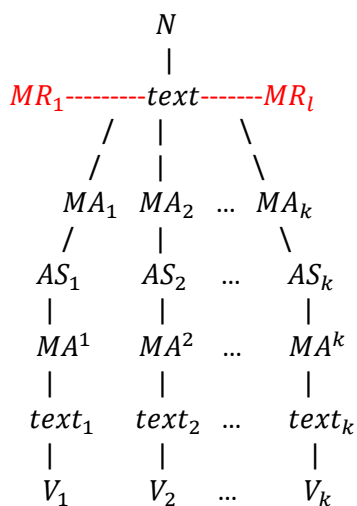
Conservation of color

Conservation of energy

Conservation of momentum

### Process for transforming raw particles into semantic structure

The purpose of this process is to associate already existing semantic particles with each raw particle in a set of raw particles. This association process may require splitting and merging raw particles from the set into another set of raw particles. The algorithm by which we transform the original raw particles through splitting and merging into a new set is discussed in the document [Semantic Parsing](#).



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<sub>i</sub>* – *V*-particle (semantic particle)

#### Match-seeker particle

Match-seeker particle is denoted with *MA* aka *MA*-particle. We do not usually depict this kind of particles in our graph representations.

Attaches to a specific property with specific prop-name and prop-value. The property value is a vector which is a key allowing the match-seeker particle to be attached to this property. The match-seeker particle exposes a pattern serving as an attraction of an association link particle which would recognize the pattern and attach to the match-seeker. Each match-seeker particle has a property ``charge`` (type ``default``) with a value indicating the strength of the charge.

$MA(key\_pattern, pvalue) - V(pvalue)$

|

$A(key\_pattern, key\_pattern2) \text{-----} MA(key\_pattern2, pvalue2) - V_{other}(pvalue2)$

#### Match Repelling particle

Repelling particle is denoted with *MR* aka *MR*-particle. We do not usually depict this kind of particles in our graph representations.

Attaches to a specific property with prop-value, a vector allowing a repelling particle to be attached to this property. The repelling particle exposes a pattern serving to repel an *association-link* particle which has a property matching the pattern. Each repelling particle has a property ``charge`` (type ``float``) with a value indicating the strength of the charge.

To each property of object particle *V* can be attached multiple *MA*-particles and *MR*-particles.

#### 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  $F$ .