# Inference and Execution of Semantic Structures

## Note on Semantic Signature of a particle

Recall, the semantic signature of compound particle is defined as shown below:

Signature of a thought particle is a matrix where .

For each particle property the property type, property name and property value of each property are stored in encoded binary format inside the binary signature matrix .

Rule for calculation of the semantic signature of a compound thought particle

which is also matrix

The last line can be written with the following syntax using radicals:

Obviously, the signature of every compound thought particle is matrix.

Every connecting particle signature encodes the operation which will be applied to the object particle on the left and the operation which will be applied to the object article on the right. Those operations and will preserve the original information contained in the signature of object particle which is being operated on with an additional information pertaining to the link particle.

### An alternative formulation of the semantic signature of

The semantic tree of the compound particle is traversed pre-order. Each particle which is a constituent of is traversed pre-order and its relevant set of properties are added to the signature sorted by type and name. Each particle property occupies a column in the signature matrix. The first particle property serves as a separator from the set of properties corresponding to the previous particle in the pre-order traversal. Recall that the property type, name and value are encoded as binary blobs and are stored as binary arrays within the corresponding signature matrix column.

Let us have the compound particle represented by its elementary particle sequence and semantic tree :

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The property sets for each V-particle are given with

and obviously the signature matrix which will be a bitmap will be composed as:

Here , , and are column bit vectors containing the binary codes which correspond to the property type, name and value of the -th property of the -th particle in the pre-order traversal of the semantic tree . Notice that the indices and in the signature matrix denote *bitwise access* – i.e. the bit which is on the -th row and the -th column in . The zones

Later we will show that the introduction of *dependent property values* will be desired ~~for paradox detection in thought sequence~~ in certain scenarios. A child particle may have properties with the same type and name as a property in the parent particle in the semantic tree of the compound particle .

Portion of the semantic tree of :

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Let us denote with one such property in the parent particle by the triplet . Then the child particle may have a property with the same type and name as the parent property and a value which is dependent of the parent property value . Let us denote by this functional dependence of the child property value. Then the child property can be written as or in short-hand notation: . For instance, definite terms and indefinite articles can use dependent property values on the parent noun.

Also in general there can be *additive overlap* between the zones corresponding to neighbor particles in the signature matrix. For instance, for and the corresponding sector of the signature matrix for the compound particle may look as:

Here denotes the binary blob which results from summation of the values and . Here the index is on the set of all overlapping columns; in this example .

## Note on vectorization of Semantic Signature

Let us have two elementary particles and represented by their corresponding sets of properties:

The property weight of a property models the semantic significance of this property and varies

The property weights for each of the two particles are denoted with:

The property weights are stored in the consumed by -particle which is a carrier of the corresponding property triplet:

such that

= {}

The pairs form a basis in property space.

Then it becomes obvious how to vectorize a particle signature: it is

where the basis vectors are represented by the tuples . The basis vectors will define dimensional vector space also known as the *property dimension* of. Obviously for composite particles the property dimension will be higher or equal to the property dimension of the elementary particles which compose it: .

Two particles and have the same semantic meaning if their vectorized semantic signatures are close enough in every property dimension. This is expressed as:

such that where is some chosen small constant which is orders of magnitude smaller than the smallest factor and the smallest -factor of the -quantum : . Since the difference between any two property values is guaranteed to be larger than the -quantum the condition which remains is as it implies the other.

If has a property with type and name not available among property set then and do not have the same semantic meaning ( abbreviated with ). Otherwise we write stating that and are equivalent semantically.

//TO DO: finish this

## Note on Semantic distance between thoughts

Let us have the thought and represented by their particle sequence and their semantic trees:

and

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Let us denote by the tree sequence where each tree in the sequence is built only from the first levels of the original tree . Here contains only the particle at the root (usually verb) while consists of the entire tree .

Two semantic trees T1 and T2 are topologically equivalent if

1. root(T1) = root(T2)
2. for childlist(root(T1)) there exist an ordering such that where 0 < i < |childlist(root(T1))| = ||
3. repeat 1) and 2) with and being the roots of the new pair of trees to compare.

We say that T1 and T2 are - equivalent if and only if all of the following is true:

1. dist(Vh, Vq) is small enough and cos(vect(Vh), vect(Vq)) is close to one and positive

## Comparing thought sequences and paradox analysis

Let us denote by a sequence composed of thoughts from a set of contexts on the same context path. Let us denote with the thoughts in , .

Let us denote by another sequence composed of thoughts from a set of contexts on the same context path. Let us denote with the thoughts in .

Let us assume that there are two thoughts and for which the semantic distance is negative.

## General Form for the Rules of inference for a sequence of thoughts

Let us denote by a thought sequence composed of thoughts from a set of contexts on the same context path. Let us denote with the thoughts in . Let us denote by a set of -particles which are entirely contained in the thought sequence such that each of the thoughts in contains at least one -particle from . The set will be the *inference trigger* which if present will kick start the synthesis of a new sequence of thoughts which will be the result of the inference. The new ordered sequence of thoughts will be denoted with . The mapping from to will represent inference operation which will be triggered by the presence of .

Let us consider the following set of examples:

*Example 1a: I do not know John.*

*Example 1b: I probably do not know John. “Probably” means I am not certain.*

*Inference a: I am not certain that I do know John. -or-*

*b: I am not certain that I do not know John.*

*Example 1c: He probably does not know John. “Probably” means I am not certain.*

*Inference: a: He is not certain that he knows John. -or-*

*b: He is not certain that he does not know John*

## Types of Inference Processes

We recognize three types of inference processes – Inductive, Deductive and Abductive inference (Peirce, 1878).

### Inductive Inference

### Deductive Inference

### Abductive Inference

Multi step process for building and refining a hypothesis

Hypothesis is synthesized and refined in a set of iterations. After it matches the input and output the hypothesis will be used for making an inference, ranked and stored for a future use.

## Learning Model for Inference Processes

Hypothesis Synthesis of new thoughts Hypothesis

## Execution of thoughts

The Execution of a sequence of thoughts implies validation analysis for the consequences of assuming these thoughts were true and linking them to other thoughts in the context path.

### Facts

*Definition of Fact*:

Executed thought becomes a fact.

### Generative-Adversarial model for thought execution

A new sequence of thoughts is formed by parsing of new statements and by recursive application of inference to the pool of thoughts within the current context path.

Simulated execution is performed resulting in the creation of Execution Plan. Alternative thoughts are formulated through alternative hypothesis formulation. Adversarial circuit parses each proposed execution plan and attempts to find a weakness in it. For this purpose the adversarial circuit compiles a ranking of facts which should not be altered/undone as there is a firm belief that these facts are correct.

Phases of the execution of sequence of thoughts

1. Parses a sequence of new statements
2. Applies Inference recursively which results into the generation of new sequence of thoughts
3. In case there is a missing link it makes a hypothesis and based on it generates new sequence of thoughts.

Execution of a thought sequence occurs when all of the following conditions are met:

1. has been inferred or parsed from a source

# Bibliography

Fischer, H. R. (2001). Abductive Reasoning as a Way of Worldmaking. *Foundations of Science, special issue on "The Impact of Radical Constructivism on Science", edited by A. Riegler, 2001, vol. 6, no.4*, 361-383.

Ian J. Goodfellow, J. P.-A.-F. (December 2014). Generative Adversarial Nets. *NIPS'14: Proceedings of the 27th International Conference on Neural Information Processing Systems - Volume 2*, (pp. 2672–2680).

Kloesel, N. H. (1992). *The Essential Peirce, Selected Philosophical Writings, Vol 1 (1867-1893).* Bloomington, IN, USA: Indiana University Press, 601 North Morton Str, Bloomington, IN 47404-3797 USA.

Peirce, C. S. (1878, August). Deduction, Induction, and Hypothesis. *Popular Science Monthly, Vol 12*, pp. 470-482.

Tesnière, L. (2015). *Elements of Structural Syntax.* Amsterdam / Philadelphia: John Benjamins Publishing Company.

Wang-Zhou Dai, Q. X.-H. (2019). Bridging Machine Learning and Logical Reasoning by Abductive Learning. *33rd Conference on Neural Information Processing Systems (NeurIPS 2019).* Vancouver, Canada.