7th Intern. **IASS/AIS-99** on *Sign Processes in Complex Systems*, October 6–11, 1999, Dresden, Germany

On Simulation and Realization.

Procedural models of sign functions in computational semiotics.

*Burghard B. Rieger**

Dept. of Computational Linguistics – Fachbereich II: LDV/CL
University of Trier, D-5428 TRIER, Germany

Abstract

In systems theory, it is common to look at systems in two ways: *externally* by its behavioral characteristics, i.e. the way how the system performs in processing (some controlled or known) input and producing (observable or measurable) outputs, and *internally* by the structural characteristics, i.e. the number and kind of variables in the system and how these variables are connected to each other, and how they interact.
Computational Semiotics is inspired by *information systems theory* according to which human beings may be taken as living *systems* whose knowledge based processing of represented *information* makes them *cognitive*, and whose sign and symbol generation, manipulation, and understanding capabilities render them *semiotic*. Whenever cognitive processes are modeled as being based upon information processing structures whose representational status is not a presupposition to but a result from such processing, then these models—being able to simultaneously initiate and modify the structures they are operating on—may qualify as being part of *computational semiotics*.
For cognitive models of natural language processing the systems theoretical view suggests to accept natural language discourse as analyzable and empirically accessible evidence for tracing such processes.
Following the systems theoretical paradigm of information processing and accepting the cognitive point-of-view, human beings appear to be very particular cognitive systems whose outstanding plasticity and capability to adapt to changing environmental conditions is essentially tied to their use and understanding of natural languages in communicative discourse. Consequently, analyzing the complexities of natural language discourse in the aggregated form of *pragmatically homogeneous text* (PHT) corpora, communicatively performative natural language texts provide a cognitively revealing and empirically accessible collection of traces of processes whose resultant multi-faceted structuredness may serve as guideline for the cognitively motivated, empirically based, and computationally realized research in *meaning constitution*.
In accordance with the theory of information systems, functions like *interpreting* signs and *understanding* meanings translate to processes which extend the fragments of reality accessible to a living (natural and possibly artificial) information processing system

*E-Mail: `rieger@ldv.Uni-Trier.de`
Internet: `http://www.ldv.uni-trier.de:8080/rieger.html`

beyond reality's material manifestations. This extension applies to both, the *immediate* and *mediate* relations a system may establish according to its own evolved adaptedness or dispositions (i.e. innate and acquired *structuredness*, processing *capabilities*, represented *knowledge*).

Modeling *semiotic cognitive information processing* (SCIP) systems' performances, the concept of *representation* is considered fundamental. To realize—instead of simulating—the experiential distinction of semiotic *processes* (of cognition) from their *results* (as representational structures) is—due to the traces these processes leave behind—a process of emergence of discernable forms of (interpreted) structures or *knowledge*.

1. Dealing with natural language structures this is tantamount to (re)presenting a term's functional potential by a fuzzy *distributional pattern* of the modeled system's state changes—rather than by a *single symbol*—whose structural relations are to depict the system's interpretations of its environment. Whereas symbolic representations have to *exclude*, the distributional representations will automatically *include* the context sensitivity of (linguistically represented) pragmatic components which a SCIP system will both, embody and employ as its own representational and procedural import to identify and to interpret its environment by means of its own structuredness.

2. In earlier attempts [1], *semantic* meaning functions have been modeled and computed as results of the same (semiotic) procedures by way of which (representational) structures emerge. Their actualization (interpretation) can be simulated by analyzing the possibilistically determined constraints found as imposed on the linear ordering (*syntagmatics*) and the selective combination (*paradigmatics*) of natural language entities (word-types) in discourse.

3. For *fuzzy linguistic* [4] lexical semantics this is tantamount to (re-)construct an entity's *semiotic* potential (meaning function) by a weighted graph (fuzzy *distributional pattern*) representing the modeled system's state space rather than by a *single symbol* whose interpretation has to be arbitrary. In this view the emergence of semantic structure can be represented and studied as a self-organizing process based upon word usage regularities in natural language discourse.

4. As *semantic hyperspace (SHS)* it may be interpreted as an internal (*endo*) representation of the SCIP system's informational states of adaptation to the external (*exo*) structures of its environment as mediated by the discourse processed [3]. The degree of correspondence between these two is determined by the granularity that the texts provide in depicting an *exo*-view, and the resolution that the SCIP system is able to acquire as its *endo*-view in the course of that discourse's processing.

5. The SCIP system's architecture is a two-level consecutive mapping of distributed representations of systems of (fuzzy) linguistic entities [2]. Being derived from usage regularities as observed in texts, these representations provide for the aspect driven generation of formal dependencies and their interrelations in a format of structured stereotypes. Corresponding algorithms select and represent fuzzy subsets (word meanings) as dispositional hierarchies that render only those relations accessible to perspective processing which can—under differing aspects differently—be considered relevant.

6. Dynamic dispositional dependency structures (*DDS*) [5] have proved to be an oper-

ational prerequisite to and a promising candidate for the simulation of content-driven (analogically-associative) reasoning instead of formal (logically-deductive) inferences in semiotic cognitive information processing by machine.
7. The dynamics of *semiotic* knowledge structures and the processes operating on them [6] essentially employ recursively applied mappings of multilevel representations resulting in a multiresolutional granularity of fuzzy word meanings which emerge from and are modified by such natural language processing. Test results from experimental settings (in semantically different discourse environments) are produced to illustrate the SCIP system's granular language understanding and meaning acquisition capacity without any initial explicit morphological, lexical, syntactic, or semantic knowledge.

References

[1] B. B. Rieger: Meaning Acquisition by SCIPS. In: Ayyub (ed): *ISUMA-NAFIPS-95*, IEEE-Transactions: Joint Intern. Conf. on Uncertainty Modeling and Analysis, North American Fuzzy Information Processing Society, Los Alamitos, CA (IEEE Computer Society Press), 1995, pp. 390–395.

[2] B. B. Rieger: Situations, Language Games, and SCIPS. Modeling semiotic cognitive information processing systems. In: Meystel/Nerode (eds): *Architectures for Semiotic Modeling and Situation Analysis in Large Complex Systems*, 10th IEEE Symposium on Intelligent Control, Bala Cynwyd, PA (AdRem), 1995, pp. 130–138.

[3] B. B. Rieger: Situation Semantics and Computational Linguistics: towards Informational Ecology. A semiotic perspective for cognitive information processing systems. In: Kornwachs/Jacoby (eds): *Information. New Questions to a Multidisciplinary Concept*, Berlin (Akademie), 1996, pp. 285–315.

[4] B. B. Rieger: Computational Semiotics and Fuzzy Linguistics. On meaning constitution and soft categories. In: Meystel (ed): *A Learning Perspective: Proceedings of the 1997 International Conference on Intelligent Systems and Semiotics (ISAS-97)*, NIST Special Publication 918], National Institute of Standards and Technology, Washington, DC (US Gov. Printing Office), 1997, pp. 541–551.

[5] B. B. Rieger: A Systems Theoretical View on Computational Semiotics. In: *Proceedings of the 1998 IEEE Joint ISIC/CIRA/ISAS Conference on Intelligent Control*, Piscataway, NJ (IEEE), 1998, pp. 840–845.

[6] B. B. Rieger: Computating Granular Word Meanings. A fuzzy linguistic approach in Computational Semiotics. In: Wang/Meystel (eds): *Computing with Words*, New York, NY (John Wiley), 1999, p. [in print].