

# Computing Meaning in Interaction

## *Computación del Significado en Diálogos*

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**Resumen:** Tesis doctoral realizada en la Universidad de Tilburg por Roser Morante Vallejo bajo la dirección de Harry Bunt (Tilburg Univ.). La defensa de la tesis tuvo lugar el 3 de diciembre de 2007 ante el tribunal formado por los doctores David Traum (Univ. of Southern California), Michael McTear (Univ. of Ulster), Reinhard Muskens (Tilburg Univ.), Emiel Kraemer (Tilburg Univ.) y Robbert-Jan Beun (Utrecht Univ.).

**Palabras clave:** Actos de habla, simulación del diálogo, actualización del contexto, DIT, grounding.

**Abstract:** PhD Thesis written by Roser Morante Vallejo at Tilburg University under the supervision of Harry Bunt (Tilburg Univ.). The thesis defence (viva voce) took place before the committee formed by doctors David Traum (Univ. of Southern California), Michael McTear (Univ. of Ulster), Reinhard Muskens (Tilburg Univ.), Emiel Kraemer (Tilburg Univ.) and Robbert-Jan Beun (Utrecht Univ.) on the 3rd of December 2007.

**Keywords:** Dialogue acts, dialogue simulation, context update, DIT, grounding.

### 1. Introduction

The general purpose of our research is to define a model of dialogue context update in the framework of Dynamic Interpretation Theory (DIT) (Bunt, 2000).

According to the theory, communicative agents can be modelled as structures of goals, beliefs, preferences, expectations, and other types of information, plus memory and processing capabilities. Part of these structures is dynamic in the sense of changing during a dialogue, as a result of the agents perceiving and understanding each other's communicative behavior, of reasoning with the outcomes of these processes, and of planning communicative and other acts. A dialogue participant's beliefs about the domain and about the dialogue partner form a crucial part of his information state, which in DIT is called his *context*. Dialogue acts are functional units used by the speaker to change the context. Formally, a dialogue act in DIT consists of a *semantic content* and a *communicative function*, the latter specifying how the information state of the addressee is to be updated with the former upon understanding the corresponding utterance. Context includes the participant's state of beliefs and goals, including beliefs about each other's processing of previous utterances.

### 2. Contributions

Our main contributions are: (i) applying the theory to the analysis of dialogue, using the DIT taxonomy of dialogue acts to model dialogues; in

particular we are concerned with modeling the effects of three groups of dialogue acts in the dialogue context: Information Transfer, Action Discussion, and Dialogue Control Feedback; (ii) assigning the model of beliefs and goals to dialogue acts; (iii) analysing fragments of dialogues by applying this model; (iv) defining a model of context update by defining certain *principles and rules*. On the basis of a detailed analysis of the flow of beliefs in a number of simple dialogue fragments, we propose certain mechanisms for modeling the transfer of information: *adoption*, *strengthening*, and *cancellation* of beliefs.

This has allowed us to explain in the form of an algorithm how information may be updated in a dialogue (Morante, Keizer, y Bunt, 2007), in particular how information may be grounded. We have proposed that grounding is the side-effect of general communication principles, and mostly the result of addressees giving feedback, implicit or explicit, to speakers (Bunt y Morante, 2007). The context update model has been converted into an algorithm and implemented in a dialogue simulator (Keizer y Morante, 2007).

In sum, our investigation has yielded theoretical and practical results. On the theoretical side, the analysis of dialogues has led to a better understanding of how the dialogue participant's context is updated as an effect of the utterances being produced. On the practical side, the context update model has been converted into an algorithm and implemented in a dialogue simulator.

### 3. Contents

**Chapter 1: Introduction** introduces the topic of research, goals, scope, and background.

**Chapter 2: Dialogue Modelling** presents a general view of the main approaches to dialogue modeling, a review of foundational literature on belief modeling, and the information state approach to dialogue management, where DIT can be placed.

In **Chapter 3: Grounding** we review various approaches to grounding, which is a dialogue phenomenon for which our model of dialogue analysis can give an account. We start by defining some concepts related to grounding, we introduce the foundational Contribution Model by (Clark y Schaefer, 1989) and two related proposals: the extension of the Contribution Model to HC interaction by Brennan and collaborators (Brennan, 1998; Cahn y Brennan, 1999), and the formal theory of grounding by (Paek y Horvitz, 2000); the computational theory of grounding by (Traum, 1994), and the treatment of grounding from the information state update perspective.

**Chapter 4: Dynamic Interpretation Theory** is devoted to introducing the theoretical framework of our research. The concepts of *dialogue act* and *context* are explained, the DIT dialogue act taxonomy is presented, and the DIT approach to dialogue management is sketched.

**Chapter 5: Dialogue Analysis Methodology** presents the methodology that will be applied to the analysis of dialogues. It consists of defining the effects that an utterance has in the context model, and making explicit general rules and principles that govern the context update: creation, adoption, and cancellation of beliefs.

In **Chapter 6: Analysis of Dialogue Patterns (I), General Purpose Communicative Functions** we analyse how the context is updated with the General Purpose Communicative Functions of Information Transfer and Action Discussion.

In **Chapter 7: Analysis of Dialogue Patterns (II), Dialogue Control Communicative Functions** we focus our attention on a group of Dialogue Control Functions: Auto-Feedback Functions. Feedback Functions are used by dialogue participants to provide information about their processing of the partner's previous utterances. Feedback can be positive or negative, and can refer to different levels of processing. The goal of this chapter is to provide an analysis for all levels and types of Autofeedback communicative functions, as defined in DIT.

In **Chapter 8: Context Update in Dialogues: a DIT approach** we analyse long dialogues, and we show that the DIT mechanisms for context update can explain how dialogue participants reach a subjective state of grounding, without the need of specific grounding mechanisms.

**Chapter 9: DISCUS: A dialogue simu-**

**lator and context update system** synthesizes the belief update process as understood in DIT in the form of a general algorithm that is implemented in a tool. The algorithm concentrates the findings of our research and it reflects what we understand to be an aspect of computing meaning in interaction, namely updating the beliefs and goals in the participant's context model. The chapter presents the tool in which the algorithm is implemented, DISCUS, a Dialogue Simulation and Context Update System.

Finally, **Chapter 10: Conclusions and Future Research** puts forward some conclusions and suggestions for future research.

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