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Alignment in Communication

Collaborative Research Center 673 at Bielefeld University

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Cooperation and coordination in action and communication have been major research issues in the cognitive sciences and the study of artificial agents in recent years. Started in July 2006, the Bielefeld CRC 673 "Alignment in Communication" investigates special modes of coordination, called alignment. Alignment covers the adaptation processes among agents which are assumed to be subconscious in humans and which do not involve explicit negotiation and control by those engaged in a common enterprise. Alignment thus conceived can be observed in human-human communication with respect to a variety of linguistic and cognitive phenomena. At the same time, alignment in human-robot communication and human interface management may serve as one of the main assets in the construction of robots and virtual reality avatars that are better tailored to human needs.

1 Project Theme: Introducing Alignment

The notion of alignment presents an innovative alternative to more established theories of human communication. The approach emphasizes the role of automaticity and routinization in bringing about common orientation at various levels of representation within and between interlocutors. We argue that the notion of alignment in communication provides a versatile, promising, and fruitful basis for a research initiative of the same name.

The general conviction that motivates our commitment is quite straightforward: We believe that human conversation is so smooth and easy because people engaged in dialogue have at their disposal an extensive pool of information, plus appropriate ways of transmission (by verbal as well as non-verbal means). With that, they can take advantage of even the most rudimentary of verbal expressions. In other words, we suggest the traditional idea that dialogue comprises an abundance of such things as ambiguous, incomplete or incorrect utterances to be abandoned. Rather, we believe that every single expression is a potential contribution to the purpose of making sense.

In consequence, we suggest research efforts to be focused on the less obvious aspects of communication: the role of automaticity, conventions, correspondence, convergence, and the like. We believe that, crucially, such a theory of communication has to be built around the notion of alignment. By this we mean the – seemingly casual – process of "harmonic orientation" (Bühler, 1934: 124) of the participants in a conversation, the state of similarity in mental structures ensuing from that, and the way such a degree of similarity is achieved. Common orientation, brought about by alignment processes, is what facilitates conversation. Common orientation exempts agents from constantly negotiating their respective points of view.

Accordingly, alignment in communication can be defined as an ensemble of verbal and non-verbal means that serve to increase the similarity in structure of two interacting dynamic systems in a largely automatic and non-reflexive fashion, without an explicit exchange of information on system states.

2 What is Innovative about Alignment?

The interactive alignment approach presents a novel research paradigm on dialogue, covering roughly the same fields as do dialogue game theory (Mann 1988) and the joint project approach (Clark 1996). So what innovative alternatives to these more established lines of research does the interactive alignment approach specifically offer?

New Insights on Language Use in Dialogue

In their interactive alignment theory, Pickering and Garrod (2004) claim that successful dialogue depends on aligned representations at all linguistic levels. In their view, global alignment arises from local alignment at any level of linguistic representations via priming: Priming at one level triggers priming at a neighbouring level; hence the processes involved are – at least to some extent – automatic. In addition, alignment is massively fostered by the interactive nature of dialogue. First of all, there is priming between interlocutors. Due to input-output coordination, parity is achieved between the representations used in production and comprehension, manifesting in joint constructions, and the fixing and monitoring of common ground. In addition, there is intra-individual priming: Alignment at the lexical level leads to alignment on the set of referring expressions used. In the same vein, syntactic priming gives rise to alignment for constituents. Finally, natural language itself provides constraints for information packaging in dialogue to be observed in order to guarantee success of linked dialogue moves.

New Impetus for a Theory of Language

Interactive alignment also has consequences for the established doctrine of linguistic theory. The existence of joint constructions in dialogue (e.g., completions, continuations, or handling of fragments) necessitates the assumption of "sub-sentential turns". As a consequence, linguistics must work with a more flexible notion of constituency than the ones adopted by most paradigms. Another argument shows the importance of implementing the notion of incrementality into dialogue-bound linguistics: Since interlocutors can only control the alignment process if some sort of feedback exists, there are linked exchanges consisting of verbal contributions and feedback signals within the confines of dialogue moves. Finally, linked representations for syntax, semantics and phonology, as well as the non-directionality of alignment (syntax does not dominate) serve as arguments for the use of constraint-based grammar or tools of comparable strength.

New Opportunities to Link Verbal to Nonverbal Behavior

Considering the effectiveness of alignment as a mechanism for information transfer, there is reason to believe that it is to be regarded as a more general principle in interactive behavior. That is, alignment may not be purely or not even be predominantly linguistic. It bears a functional resemblance to the automatic links that exist between perception, conception, and behavior – the so-called perception-behavior expressway (Dijksterhuis & Bargh, 2001). Indeed, instances of alignment can be found at every biological level – from the neuronal level with oscillatory processes causing synchronization of cell assemblies to the eco-systemic level with the complex interplay between predators and prey populations. In a similar vein, alignment appears to be at the very basis of a perception-behavior link and to be responsible for all sorts of unconscious imitation.

Understanding Alignment Through Simulation with Artificial Agents

Basic research on interactive alignment can benefit from computational models of the structures and processes investigated. Computational modeling has, in fact, been rendered prominent among the desiderata for the scientific study of alignment (Brown-Schmidt & Tanenhaus, 2004). Accordingly, computer-based simulation models play a prominent role in the investigation of dialogue systems and the emulation of artificial interlocutors. Recent work aims for embodied agents, be it robotic or simulated ones, that are to engage naturally with humans in multimodal conversational and collaborative interaction (e.g., Cassell et al., 2000;

Oviatt et al., 2004; Kopp et al., 2003; Fink et al., 2004). Cognitive robotics has begun to construct systems that illustrate how behaviors achieving interaction abilities of physical intelligent agents can be acquired and implemented, on anthropomorphic (Minato et al. 2005) as well as non-anthropomorphic platforms (Kanda et al. 2004). Creating, evaluating, and systematically modifying dialogue simulation models and artificial systems that reproduce certain aspects of a natural system helps to understand the internal mechanisms that have led to the particular results.

Alignment as a New Avenue for Interactive Information Systems

A large body of work in artificial intelligence and agent research aims at advancements of the interaction between humans and machines. A growing number of researchers have already realized the relevance of user adaptation for interactive systems, but so far many of them narrowed down to desktop-style interaction. Existent systems try to build explicit models of the user or the task from information gleaned from monitoring the user's interaction. These representations are then processed by some form of inference or decision making to adapt to the individual user, e.g., by adjusting dialogue strategies, by taking over routine tasks, or by tailoring information presentations. Moreover, taking an alignment-based approach to human-computer interaction means to build systems that appear as embodied interlocutors in face-to-face dialogue, and it means to enable them to establish coordination with their human interlocutors not only by means of explicit negotiation and reasoning but also by taking account of the more fine-grained, non-deliberate mechanisms of alignment we find in everyday human-human communication. It stands to reason that these capabilities can bring about substantial benefits for the intuitiveness, efficiency, and acceptance of human-computer interaction.

Taken together, the interactive alignment approach puts more emphasis on agents' coordination than on questions of well-formedness and coherence in dialogue, contrary to what has been customary practice in linguistics to date. It also constitutes a step towards bridging the gap that exists between the (monologically oriented) "language as product"-tradition and the (dialogue-oriented) "language as action"-tradition (cf. Tanenhaus & Trueswell, 2004).

We believe that our research initiative focused on this 'new side' of communication will substantially contribute to the theoretical development in the humanities and, at the same time, bring about practical advancement in technology. The ultimate purpose of such a research initiative is to extend our knowledge about the cognitive processes underlying language production and comprehension in human-human communication as well as in natural language use in human-machine interaction.

3 Who is involved?

In more than a decade of intensive research on "Situated Artificial Communicators" (CRC 360), a team of linguists, psychologists, and computer scientists at Bielefeld University have jointly tackled questions of information processing in task-oriented communication – to the effect that the role of key notions such as context, integration, reference, coherence and robustness has been explored in great depth (Rickheit & Wachsmuth, 2006). From among this team of researchers and new faculty, the current research program has been established.

For investigating the multiple – inherently dynamic – facets of alignment in communication, again, an interdisciplinary approach must be taken. Our research effort brings together linguistics, artificial intelligence, neuroinformatics, neurolinguistics, computational linguistics, and psycholinguistics, employing a conjoint methodology that integrates theory, description, and experimentation with simulation and evaluation. Research teams and principal

investigators come from Bielefeld University's Faculty of Linguistics and Literary Studies as well as from the Faculty of Technology (see acknowledgment).

Different fields, methods and technologies are tied together to yield a comprehensive account of alignment phenomena. While certain limitations arise from the fact that the alignment account requires further empirical support and some conceptual clarification, and that the interface of alignment and negotiation in conversation is not very well understood to date, these shortcomings inherently carry some of the scientific potential of our research endeavor.

4 Project Structure and Methods

In general, alignment data will be investigated using methods from linguistics, psycholinguistics, logics, game theory, and AI. The methodology followed is to use statistics on experimental data for establishing domain-relevant theories, simulate these using AI-tools, e.g. from robotics and virtual reality, and test them on independent new data. In this context, two methodological limitations have to be dealt with: Automatic alignment calls for fine-grained mechanisms to model agents' rational behavior. In this field a hybrid of game theory and logics will be used. Furthermore, empirical data usually do not admit of clear-cut categorizations. In order to overcome this fact and fix divides, especially in data-description and statistical investigation, simulative data-modelling using virtual reality will be carried out. Since most projects generate data which have to be worked on, special attention is given to the development of corpus management tools, annotation systems and statistical modelling.

Interpersonal alignment

Interpersonal alignment covers the adaptation processes among agents which do not involve explicit negotiation and control of those engaged in a common enterprise. Alignment thus conceived is to be observed in human-human communication with respect to the use of words, especially neologisms, the creation of new senses, copied patterns of syntax, recycled referring terms, the evolution of patterns in dialogue structure such as the use of ellipses and fragments. In the multi-modal settings which generate the main bulk of the experimentally established empirical data of the CRC, interpersonal alignment will also be studied in the coordination of gaze emerging among co-operating agents, in the arousal of collective intentions and emotions, or in several agents' establishing a common gestural space for deictic communication.

Intrapersonal alignment

Any explanation of dialogue would be incomplete without taking into account the cognitive prerequisites for alignment on the side of each of the participants, for instance, with respect to the synchrony of an agent's gesture and speech. Therefore, we investigate alignment also with respect to intrapersonal information processing in conversation. Alignment – through priming or through routines – can be viewed as a means to facilitate language production or comprehension by automatising decisions so that individual language users take a minimum of cognitive effort to make a maximum of sense (an aspect that Hörmann, 1976, has referred to as "sense constancy").

Systemic aspects

Investigating interactive alignment from a systemic perspective promises to bring about cross-fertilization between language research and computer science. In human-computer interaction that addresses increasingly comprehensive accounts of communication, alignment can be a catalyst to increase intuitiveness, efficiency, and acceptance. Simulation with computational models as a research method offers benefits for the scientific study of alignment. For the design of interactive information systems it yields a new impetus for developing more elaborated cognitive interaction technology. Finally and more generally,

alignment as a principle for information processing inspires new approaches for organizing the efficient cooperation of complex systems under the constraint of an 'informationally narrow' coupling.

It is our conviction that, from the perspective of basic research, operational models can advance our understanding of the key aspects of interactive alignment. From an application perspective, they are positioned to provide well-grounded support to simulate the behavior of human interlocutors and to construct 'anthropomorphic' interfaces that are better tailored to the needs and expectations of human users.

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A2 Processing of implicit common ground
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A3 Dialogue games and group dynamics
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A4 Alignment of situation models
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A5 Alignment of attention in mediated communication
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B1 Speech-gesture alignment
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C1 Interaction space
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C2 Communicating emotions
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C3 Repairs and reformulations in dialogue
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C4 Adaptive alignment in human-robot-cooperation
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C5 Alignment in AR-based cooperation
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X1 Multimodal alignment corpora: statistical modelling and information management
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