

A Missing Link: The Role of Semiotics in Multiagent Environments

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ABSTRACT

Approaches to artificial intelligence research based on autonomous agents have thus far primarily relied on cognitive science and other psychologically motivated approaches to the social world. These approaches have been a logical outcome of the researchers' concentration on agent building. However, recent developments in the field have revealed the need for a wider and primarily socially centered interpretive framework in which to account for or model the agents' behavior. Dautenhahn's attempt to interpret the agents' social behavior has been based (frequently only implicitly) on macro-sociological approaches and biologically motivated evolutionary determinist theories. In order to make autonomous agents truly "socially intelligent", researchers will sooner or later need to take microsociological theories into consideration. The fact that these theories are interaction and communication-centered opens up the possibility for a relevant application of semiotic theories in the field of AI.

This paper outlines the elements of several classical semiotic theories potentially useful in current and future AI research centered on autonomous agent modeling. Briefly discussed are Greimas-Courtes's distinction between actor and actant, Tartu-Moscow school notions of semiosphere and culture as secondary modeling system, Jakobson's notion of the functions of language, and Eco's semiotic approach to semantics, as expressed by his notion of cultural encyclopedia.

General Terms

Theory.

Keywords

Artificial intelligence, behavior-based AI, autonomous agents, socially intelligent agents, multiagent environment, semiotics, microsociology, actor, actant, semiosphere, secondary modeling systems, Jakobson's communication model, cultural encyclopedia.

1. INTRODUCTION

Recent developments in the field of AI have brought to the fore the need to account for the social aspects implicit in user-agent interaction or agent interactions taking place in artificial environments without human control. Indicative of the "social turn" in the field is the use of terms such as "socially intelligent agents" and "social embeddedness", as well as the titles of journals, research projects, and symposia¹. Although some researchers have used social conceptions to describe the interplay of artificial agents in multiagent environments, these descriptions have sometimes been discarded by sociologists as "folks sociology"[17] or thought of as "blindly perform[ing] a one-to-one mapping of sociological concepts to computer models"[19]. The task of disciplinary collaboration between the disciplines of sociology and distributed AI has been described as a "painful" one[19].

Approaches to artificial intelligence research preceding its current social focus relied primarily on cognitive science and other psychologically motivated approaches to the social world, which

¹ A major source of information in this research area has recently been *Journal of Artificial Societies and Social Simulation*. In 2001, this journal organized a symposium and published a special issue on the topic "Starting from Society: the Application of Social Analogies to Computational Systems" (vol. 4, no. 1). Other journals and conferences have also presented articles and papers on "socially situated AI", "social intelligence" and "socially intelligent agent-building". A major research project funded by the German Research Foundation ("Socionics") has been set up in order to "start a serious evaluation of sociological conceptions and theories for computer systems", with the aim of "developing intelligent computer technologies by picking up paradigms of our social world"[19].

was a logical outcome of the researchers' concentration on agent building.

Recent attempts of a prominent researcher trying to interpret the agents' social behavior[6] have been based (frequently only implicitly) on macrosociological approaches and biologically motivated evolutionary determinist theories. What is obviously lacking in the field is a sustained effort to interpret user-agent and artificial agent interactions in microsociological terms².

However, in order to make autonomous agents truly "socially intelligent", researchers will sooner or later need to take microsociological theories into consideration. The fact that these theories are interaction and communication-centered also opens up the possibility for a relevant application of semiotic theories in the field.

This paper outlines the elements of several classical semiotic theories potentially useful in current and future AI research and agent modeling. Briefly discussed are Greimas-Courtes's distinction between actor and actant, Tartu-Moscow school notions of semiosphere and culture as secondary modeling system, Jakobson's notion of the functions of language, and Eco's semiotic approach to semantics, as expressed by his notion of cultural encyclopedia. Examples of interaction that illustrate the potential usefulness of theories discussed are taken from the field of behavior-based AI³, and specifically from the Carnegie Mellon University's Oz project (cat Lyotard and Woggles) and Stanford University's Virtual Theater Project (the Servant/Master Scenarios)⁴.

2. "ACTANT" AND "ACTOR" AS QUALIFIERS OF SOCIAL AGENCY

In any attempt to interpret the interactions taking place in multiagent environments from a sociological point of view, it is important to use the term "social agency" in addition to "social behavior", which almost immediately implies a more psychological approach and behaviorist stimulus-response model⁵. In order to further qualify this term and gain a more

² The need to take into account the microsociological focus in the field has been announced by works such as Agre's 1988 Ph.D. thesis on *The Dynamic Structure of Everyday Life*[1] and by the individualist micro-approach of Edmonds's articles [9] and [10].

³ A detailed account of terms used in the field of "new" or "alternative" AI can be found in [18] and [21].

⁴ Detailed accounts of these interactions as well as general information on the emergence and architecture of believable agents developed within the Oz project can be found in [2], [3], [4], [16] and [18]. These articles and a general presentation of the project are presented at the project web site (<http://www.cs.cmu.edu/project/oz/web/papers.html>). Details of Master/Servant Scenarios, developed within The Virtual Theater Project, are described in [12] and presented at <http://www.ksl.stanford.edu/projects/cait/demos/status.html>

⁵ One obvious exception to the psychological-behaviorist coloring of the term "social behavior" is its use in Goffman's micro-

complete understanding of the nature and consequences of interactions taking place in multiagent environments, a semiotic distinction between the terms "actant" and "actor", as explained by Greimas and Courtés[11], can also be introduced into discussion.

Based on Greimas's work in narratology, this distinction primarily relates to an interpretation of semiotic phenomena in the medium of natural language, and not to an interpretation of society. However, social relations are clearly implied in the subject-matter and analytical procedures of narratology and, because of this, the distinction is obviously welcome in microsociological accounts of interactions as well.

Greimas and Courtés state that the term "actor" has gradually replaced "character" and "dramatis persona", extending its use outside the purely literary. This is especially interesting in the field of "behavior-based AI" in which theater terminology ("virtual drama", "interactive drama", "character", "story", "scene", "drama manager") is frequently used. In this context, the distinction between the terms "character" and "actor" can be seen as a shortcut to analytically highlighting the social component implicit in the networks of relations forming in "fictional" multiagent environments.

An even more complete understanding of the social implications of actions performed by "characters" in "interactive dramas" can be gained by introducing a further distinction between the terms "actant" and "actor".

Quoting Lucienne Tesnière, from whom they borrow the term, Greimas and Courtés state initially that "actants are beings or things that participate in processes in any form whatsoever, be it only a walk-on part and in the most passive way"[11]. In simple terms, "an actant can be thought of as that which accomplishes or undergoes an act, independently of all other determinations"[11]. From a sociological perspective, the term "actant" is stimulating because it pairs off with the notions of role and status ("actantial role", "actantial status"). As narration (in the sociological context, "social process") unfolds, an actant can take on a number of actantial roles.

According to Greimas and Courtés, actantial status is "that which defines the actant at a given moment of the narrative trajectory, taking into account the totality of its previous trajectory (manifested or simply presupposed)"[11]. Actantial role, on the other hand, is defined as "simply the surplus which is added, at a particular point of trajectory, to what already constitutes the actant within the syntagmatic progression of the discourse"[11].

The distinction translates easily into the artificial behavior-based multiagent environment. Behaviorally animated autonomous agents Gregor and Otto in the Master/Servant interaction can be thought of as "characters" with predefined actantial status and actantial roles implied by that status (i.e. expected at the particular point of trajectory at which they find themselves at the moment when interaction takes place). However, what happens during the

sociological theory. The term "social agency" has been used as a hallmark of sociological approach since Weber introduced it in his 1921 study *Wirtschaft und Gesellschaft: Grundriß der verstehenden Soziologie*.

interaction is a reversal of actantial roles and a corresponding reversal of actantial status, which turns Gregor and Otto into individualized interaction entities better described by the term "actor".

In contrast with "actant", "actor" is "not only the point of investment of [actantial and thematic] roles, but also of their transformations, since discourse consists essentially of the interplay of successive acquisitions and loss of values"[11].

This definition makes it possible to introduce microsociological approaches into the discussion of interactions taking place in multiagent environments. In the course of an interaction the actor not only demonstrates actantial status and role, but is also "incorporated into the discourse" and "maintained throughout the discourse - or at least throughout a discursive sequence - in keeping with the principle of identity"[11]. Through various narrative and semantic investments, the actor acquires the appearance of an autonomous figure in the semiotic universe.

From a sociological point of view, this notion would correspond to a "social actor" manifesting itself as an autonomous figure in "social interaction" (i.e. in society presupposed by it), and would obviously include Gregor and Otto of the "Servant/Master" interaction.

3. BIOSPHERE, SEMIOSPHERE, SECONDARY MODELING SYSTEMS

Given the current foci of interest in both disciplines, the most pertinent application of semiotic methodology developed within the Tartu-Moscow school to the field of AI would at first glance seem to relate to the current reelaborations of the late Lotman's distinction between biosphere and semiosphere.

Lotman derived the notion of semiosphere from V. Vernadski's biosphere and conceived of it as an abstract space in which languages, texts and cultures intertwine[23]. According to Lotman, semiosphere is the world as defined by the semiotic competence of living organisms. The process of sign generation (semiosis) would be unthinkable without it. However, this does not mean that this abstract sphere is cut off from what does not belong to it. What crystallized as the most important notion connected with semiosphere is the notion of the boundary, through which it is in contact with the non-semiotic and alien semiotic space. Semiosphere is highly porous (i.e. perforated by multiple inner boundaries) which make possible translation of external messages into its internal space and vice versa.

Researchers who approach the notion of semiosphere from a biosemiotic point of view have also come up with the distinction between "vertical semiotic system", which relates to genetic communication down through the generations, and "horizontal semiotic system", which relates to the communication throughout the ecological space[14]. It is through this kind of horizontal communication that semiosphere, conceived of as an autonomous sphere of communication emerges[13]. According to Hoffmeyer, horizontal communication is also a precondition for advanced social complexity and learning processes that bring it about.

Given the embodied nature of autonomous agents and the emergence of social aspects in their interactions, as well as the importance of learning processes in the field, the emphasis put on the social effects of horizontal semiotic communication would seem to possess an obvious significance in multiagent

environments. From a sociological point of view, when higher levels of complexity are reached in this environment, parallels could even be drawn between the notion of boundary, central to the notion of semiosphere, and the notion of the boundary as described by Luhmann.⁶

However, the current level of development of autonomous agents imposes restrictions on the use of notions such as biosphere and semiosphere, as well as on the application of sociological theories of a corresponding level of generality. Regarding the technical limitations in the construction of agents, there are on the one hand purely textual agents (such as the cat Lyotard, developed within the Carnegie Mellon University's Oz project) with minimal metaphorical "biosphere" and, on the other hand, agents (such as Woggles, also developed within the Oz project) with physical attributes but very limited "natural language" capabilities. In addition to this, interactions taking place in multiagent environments have thus far resulted only in low levels of social complexity.

At the current level of development, an earlier distinction made by the members of the Tartu-Moscow school would seem to be more fruitful as a means of describing and modeling interactions in multiagent environments. This is the distinction between the "primary modeling system" and "secondary modeling systems". In this context, natural language is seen as the primary modeling system in relation to reality, while the "languages" of culture (only some of which use the natural language as "raw material" but all of which can be interpreted by it) are referred to as secondary modeling systems. These systems comprise "not only all the arts (literature, cinema, theater, painting, music, etc.), the various social activities and behavior patterns prevalent in the given community (including gesture, dress, manners, ritual, etc.), but also the established methods by which the community preserves its memory and its sense of identity (myths, history, legal system, religious beliefs, etc.)"[20].

The only area of secondary modeling systems currently applicable to multiagent environments is obviously the area of "various social activities and behavior patterns prevalent in the given community". The behavior patterns with which agents enter interactions to some degree always resemble those involved in human interaction in a particular culture (in the same way as believable agents are always anthropomorphically modeled).

⁶ A footnote is in order to account for mentioning of Luhmann's theory in the context of a paper insisting on the need for researchers to interpret the agents' social aspect from a microsociological perspective and with the help of semiotic theory. Luhmann's theory approaches social systems at roughly the same level of generality as the notions biosphere and semiosphere do. Its general approach is macrosociological but it effectively combines elements of macro- and micro- approaches in its analytical procedures. In discussing the emergence of sociality in multiagent environments, we are currently preoccupied with an analysis of interactions that bring it about and that can in our opinion be best accounted for from a microsociological perspective. When higher levels of complexity are reached, the application of top-down approaches could also be stimulating, especially when they are communication-based as is the case with Luhmann's theory.

Likewise, the emergent social aspects of multiagent environment interactions can be interpreted with the help of methodology developed to account for interactions that take place in exclusively human environments. Given the current level of development of techniques of agent interaction, Goffman's "dramaturgical analysis" would seem to be the most pertinent approach in this regard, because it emphasises and is capable of effectively interpreting non-verbal elements socially meaningful in interactions.

4. FUNCTIONS OF LANGUAGE IN MULTIAGENT ENVIRONMENTS

Roman Jakobson's classical account of language functions[15] was developed within a communication model dealing only with verbal communication, but could be said to be general enough to retain its explanatory value in environments which are neither purely verbal nor exclusively human.

The six function schema is applicable to interactions in which there are at least an addresser (sender) and an addressee (receiver), a message to be shared, a context of the sharing, a channel through which the message is shared and a code which makes sharing possible. Each of these elements determines a particular linguistic function. The emotive (or expressive) function relates to the addresser and conveys his/her attitude towards the message, the conative function relates to the addressee (i.e. to what the addresser wants the addressee to notice or do), and referential function to the context (i.e. to what is being spoken of). The phatic function "checks whether the channel works"[15] and is typical of the use of language which helps maintain a social relation (contact) through ritualized formulas, while the metalinguistic function is used by the addresser and addressee "to check up whether they use the same code". Finally, the poetic function "focus[es] on the message for its own sake" and in this way "promot[es] the palpability of signs"[15], by means of the repetitions of sound values, stresses, accents, as well as associations and ambiguous boundaries between words and phrases. "Self-focused message[s]" [15] are typical of poetic discourse, but also have a role to play in everyday communication.

In the interactions of anthropomorphic animated puppets (Woggles), as described by Loyall and Bates[16], note can be taken of functions corresponding to Jakobson's referential, conative, emotive and phatic function. Woggles refer to their context, address one another, express emotions and communicate in order to maintain an elementary social ritual.

The interactions of Woggles obviously fall short of the complexity of human communication, but the four functions of language evident in them suffice to situate the agents into the field of sociality (which according to microsociological theories emerges as the consequence of interactions).

5. CULTURAL ENCYCLOPEDIAS IN AGENT INTERACTION

One of the premises underlying symbolic interactionist theories postulates a minimum of the common "definition of the situation"[22] in order for an interaction to take place. Translated into the theory of information-based terminology, this would imply the necessity that the sender and the receiver share the same code in order for the message to be transmitted. However, a

somewhat more complex definition is needed to describe interactions which include attitudes and values, i.e. social competences.

The necessary elements of a definition potentially useful in interpreting and modeling the social aspects of the interactions of autonomous agents can be found in Umberto Eco's semiotic approach to semantics. In his theory of semiotics[7] and a subsequent account of interpretive cooperation in narrative texts[8], he developed the notion of "cultural encyclopedia", by which he describes "a model of socialized competences at a particular point in history, which the dictionary (a model of ideal competences of an ideal speaker) cannot explain in full measure"[5] [translation M.P.].

Interactions taking place in multiagent environments at the current level of development obviously cannot be expected to parallel the complexities of human interaction. In addition to this, the "approximate and sometimes even illogical" constitution of the cultural encyclopedia represents one of the major problems in the field of AI[24] [translation M.P.].

In spite of this, it is evident that "emotional engines" of the aforementioned believable agents have already been modeled in accordance with principles that correspond to the implications of Eco's notion of cultural encyclopedia. For example, in the emotional engine of the purely textual believable agent developed within the Oz project (cat Lyotard), "human" is defined as somebody whom the cat dislikes. In the course of interaction, Lyotard gets food from the human and is pet by the human, and the human becomes somebody liked by the cat.[4]. What has changed in this brief interaction is Lyotard's rudimentary cultural encyclopedia of the "human"⁷. The fact that the notion of cultural encyclopedia includes the possibility of change is very important in the field of behavior-based AI, because of the importance of the learning process.

6. CONCLUSION

The relevance of the elements of classical semiotic theories outlined in this paper to the field of behavior-based AI is potentially twofold. On the one hand, it is conceptual (they help us understand the nature of interactions taking place in multiagent environments), on the other hand, they could also have practical consequences in the modeling of agents and interactions.

⁷ Attitudes and values are important elements of the approach to semantics based on cultural encyclopedias (in contrast with the previous, more strictly defined "dictionary"-based approaches). It should be said that, at the current level of development, Lyotard's cultural encyclopedia of the "human" in effect consist only of the attitude toward the human. Nevertheless, what changes in the human-cat interaction described in [4], can be viewed as a change of cultural encyclopedia and not merely a change of an attitude. Other attributes (semantic markers) can be added to the notion "human" at a later stage of development. Gregor's and Otto's more complex cultural encyclopedias of the terms "master" and "servant" did not change in the course of the "Master/Servant" interaction described by Hayes-Roth, Van Gent, and Huber [12], although the agents reversed their roles and status.

These theories could prove to be an important link between the researcher's concentration on agent-building and the need to account for the emergent social aspects implicit in agent interaction. What needs to be done in order to make them fully effective in this regard is to explore their interrelations with selected microsociological theories and the possibilities of their combined application in the field of autonomous agents.

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