The EthnoAgent

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Abstract. We present the model of a realised system which is intended to take in account the cultural claim inside the frame of the cognitive science.

1 Introduction

Ethnomethodology[2] and Cultural Psychology contributed to a radical paradigmatic shifting in many fields of the human sciences, from a “psychological” approach to a “social” one, although misunderstandings arose with exponents of the cognitive approach. This paper proposes an interaction model rooted in the symbolic tradition, which nonetheless takes in account the main reason of this shift.

All works on modelling interaction belong to either the intersubjective tradition or to the symbolic one. The former focuses on the relation between the agent and the environment, the second one focuses on knowledge representation. Examples of the former are [8], [4], [9]. All those share the Garfinkel’s anti-mentalist criticism. The symbolic approach criticizes former: according to Castelfranchi [3], the ethnometodologists fail to account for individual intentions and planning. The second approach replaced the game recognition problem by the well-known intention recognition problem.

In the first part of this paper, we sketch some of the main ethnomethodological results on human communications. At the end of this incomplete summary, we state some conditions that an interaction model must satisfy. In the second part, we propose an interaction model, which uses Dialogue Games and it satisfies those conditions. In the conclusions we state some considerations about the model.

2 An Analysis of Two Interactions

The first transcription to be discussed in this part was recorded and published by Sacks [10]. It is part of a classical contribution to conversation analysis (CA); the second is still unpublished.[3]

Transcription 1 reports a fragment of a telephone call to a help line. Transcription 1 follows the typical greeting sequence. The caller is anonymous. Both caller and respondent are male. This fragment is important because it contradicts our common-sense model of interaction. According to it, the story telling process is a flow of information.

Transcription 1 (A is the answerer, B is the caller)
(1)A: Yeah, then what happened? (2)B: Okay, in the meantime she [wife of B] says, Don’t ask the child nothing. Well, she stepped between me and the child,and I got up to walk out the door. When she stepped between me and the child, I went to move her out of the way. And then about that time her sister called the police.I don’t know how she? what she? (3)A: Didn’t you smack her one? (4)B: No. (5)A: You are not telling me the story, Mr.B. (6)B: Well, you see when you say smack you mean hit. (7)A: Yeah, you shoved her. Is that it? (8)B: Yeah, I shoved her.
In this initial interaction fragment, A must be considered completely unaware of the story. According to the common sense model, the access to the story is direct for the teller and is mediated for the listener. It seems reasonable that A, who does not have any direct access to the facts, will trust B’s account.

But at step 3 (A: Didn’t you smack her one?), A introduces a new element. According to the intended model, step 3 would be interpreted as A’s attempt to guess the next part of the story. So, what A says is what A believes that B knows and B is telling.

If, according to the intended model, A’s act is an attempt to guess the next development in the story, at step 4, B’s ”No” will involve A in an activity of belief revision which will not involve B. In fact A’s guess was contradicted by what B said. B will not be involved in belief revision because he knows the story.

Now we look at what happened at step 5 (A: You are not telling me the story, Mr. B.). What A states contradicts the story told by B. This is completely unforeseen by the model. Why did A make such a strong statement without any possibility of acceding to the facts? In addition, the fact that A contradicts B’s story is in contradiction to the fact that B is A’s only possible source of information. With this first observation we state that A is assuming the intended model. Now we look at B. If B assumes the intended model he will react to (5) in a way similar to (6*):

(6*) you don’t know either the story, my wife, her sister! Wait and listen.

However, the sequence 6-9 doesn’t follow the model prevision. B agrees with A’s objection and he seems to consider it pertinent. The sequence 6-9 is a typical example of meaning negotiation. Sacks [10] states that an alternative analysis of that interaction could have been made assuming the existence of a shared intersubjective collection of structures. Following such an analysis at step 3, A’s action could be interpreted in two different ways: as an attempt to guess the outcome of the story, and as the addition of a necessary element to it.

At step 4, B seems to interpret A’s move as an attempt to guess B’s story. At this point B’s ”No” seems to end A’s guessing attempt.

At step 5, A’s action clarifies, 3 was not an attempt to guess. In addition, in step 4, B’s refusal of A’s added element put A in the condition of stating that B’s story with the refusal of the element is inconsistent with respect to the set of assumptions of an intended structure, which is intended to be pertinent. In fact, this is what A does at step 5. At step 5, Sacks states that A’s implicit reasoning could be seen in the following way. You have said *p*, your sister in law called the police. You told me also: *a*, *b* and *c*. We both know that *p* needs *a*, *b*, *c*, and *g*, where *g* is the ground for the police calling. At

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[2] Ethnomethodology is the scientific study of human procedures. For the purpose of this analysis, we consider Ethnomethodology and Conversational Analysis as synonimus.

[3] I thank Anna Maiorana for reporting this conversation to me.

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step 3 I asked *g*, you told me "no". Your story is inconsistent, so you are lying.

Only a description of steps 1-5, which implies shared resources, is coherent with the fact that B accepts and considers pertinent A's claim. In addition, that model foresees the sequence 6-9. In fact, B must reformulate his story in a way, which is coherent with the implicit shared structure.

Sacks' point is that in order to understand some pieces of interaction like these, we must postulate a set of shared structures. In the presented case, it is only this assumption that makes it possible to build up a model, the previsions of which are not contradicted at each step.

By analysing this interaction, we have emphasized the first element that we consider in the formulation of the model. In a communicative process, the meaning of the action is subsumed by structures that are compatible with the history of the interaction, the beliefs of the participants and the set of the inter-subjective structures presupposed by the agents. It is only the use of this set of intersubjective structures that allows the agents the possibility of refusing a story without having direct access to the facts.

In order to focus on the other two elements of the human communication, we refer to Transcription 2.

Transcription 2 (C is a child, M is a mother, and S is a baby sitter) *(1) B: Now the pizza is ready (2) M: Don't touch the clothes peg (3) B: [Starts crying] (4) S: Wait (.) wait (5) S: The pizza is ready now (.) we have to put it in the oven (6) B: [B stops to cry and gives the clothes peg to S]*

At step 1, B is playing with a clothes peg, using it as flour. At step 2, M notices that B is handling the clothes peg. M worries that B may lose it, and M orders B to give the clothes peg back. At step 3, B refuses and starts to cry. At steps 4 and 5, S acts. First, S focuses the attention on herself. Then after a pause, expressed in the notation by (.), S states that they must put the pizza in the oven. At step 6, B agrees; she stops crying, and gives the clothes peg to S. According to the previous analysis, we model this interaction in the following way. B is playing the Cooking game. M asks for the clothes peg from B, this action could be seen as a move in the game, in which the goal is to retrieve an object from the child. we call this game the Retrive game.

B knows that if she accepts M's game, she will not finish hers. B knows also that she could not sustain the Confrontation game with M. For B this involves frustration that makes her cry.

Castelfranchi gives the following definition of frustration. An agent A undergoes a frustration, at a time t_1, if at a previous time he believes that he could reach a certain state x. x is in his set of goals, at the time t_1, A discovers that he will not reach x but x is still in his goals set.

S plays a move that agrees with both B's and M's game. In fact, M saves the clothes peg and B completes the cooking. To meet this goal, S must identify both games and she chooses a new alternative one. It is hard to believe that S is provided with a set of games for each possible situation she could encounter. To my mind, S's behaviour suggests that we could build up a huge set of games from a basic game set and a set of rules. The set of rules may define a grammar.

In my analysis, I'll call the game played by S in this fragment Mediation. It is in fact a meta-game. It consists in identifying a game for each of the other players and choosing a new game, which will be accepted by the others because it provides a better result for everybody.

This fragment is also interesting for other reasons. It shows that we could provide more possible accounts for the same piece of interaction. We could believe that M would deliberately frustrate B or that M doesn't know what effect her acts could have on B. This suggests the following conclusion: in a communicative process each agent knows the signals he receives, but he never knows for sure which game each other agent is conducting. It is always possible that the agents involved in an interaction are sure of playing the same game but in fact are not. They subsume the meaning of each other's actions from different structures.

This observation permits us to focus on an apparent communicative paradox. The interpretation that an agent A gives to a set of communication actions of another agent B is subsumed by a structure of A compatible with A's beliefs on B. But if we say A interprets B's communicative actions, we don't mean that A is looking for one of his internal structures coherent with B's action. This could be true in the domain of physics. It also doesn't mean that A is looking for B's best structure to account for B's behaviour. This may be true in the domain of behaviouristic psychology.

According to our analysis of the first interaction, I believe that, if A is looking for B's communicative action meaning, A is not simply looking in his private set of structures for the one which is compatible with B's action. What A is looking for is in some relation to the structures shared between A and B. It is unrealistic to state that A is looking for B's private structure to explain B's action. Not only because A does not have access to B's private state. In the case of communicative action, A knows that B's action is a communicative one. This knowledge forces A to seek B's interpretation not in all the possible structures that A refers to B, but only in that which A believes that B believes to be known to A. We could reiterate this discourse as many times as we want. The result is that we should consider pertinent only the structures, which are believed to be common knowledge.

It is hard for an agent to interpret a signal because the interpretation is a function of the context, but until the interpretation of the signal is clear, the context is not clear at all. Basically, the interpretation problem is an inversely posed one. In fact, to interpret a signal means to give it a meaning. The interpretation of a signal is the result of its context function given the move associated with the signal as input. The presupposition that a set of structures is shared between the agents does not solve this paradox. It cannot be solved because the context of a move is both a resource for the interpretation and a product of the interpretation.

To summarize, this analysis yields two bad results: first, the interpretation problem is an inversely posed one, and second, S's behaviour seems to show that the number of games is huge, if not infinite. In the next part of this paper, I'll show a communicational model, which takes into account ethnomethodological results in dealing with such a discomforting scenario.

3 A Model for Communication and Mutual Understanding

3.1 ***The Interaction.*** It is a process which involves two or more agents in an environment. The agents act and account for each other's actions according to their own internal state, which includes the hypothesis that a particular game is going on.

In this model, we use i to indicate an interaction situation, and by I we indicate the set of i. Each agent's action and environmental event is linked to signal. In an interaction situation each agent could see the signal associated with the moves played by the others, but not see directly which moves it has played. So the agents may suppose the moves played. In order to represent i we employ a Multi Context

System.

A *Multi-context* is defined by a couple $(\{c_i\}_{i\in I}, Br)$ where $\{c_i\}_{i\in I}$ means a set of contexts and Br is a set of bridge rules. By a context we mean an incomplete representation of a reality domain. A context is a cognitive representation of a local ontology.

In particular we use formal contexts. A formal context consists in three elements:

$c = (A, B, I)$

where A is a set of proprieties, B is a set of objects, and I is a function, called "information function",

$I : A \times B \to \{0, 1\}$.

We relate those contexts by a set of bridge rule. The following is its general form:

$\frac{c_1:\phi_1,\ldots,c_n:\phi_n}{c_{n+1}:\phi_{n+1}}$

where: $c_1, .., c_{n+1}$ indicate different contexts, $c_1 : \phi_1, ..., c_n : \phi_n$ indicate well-formed formulas belonging to the contexts: $1, ..., n$, and ϕ_{n+1} indicates a formula in the context c_{n+1}. Here, the set of contexts represents both the agents and the environment. The set of bridge rules represents the signals. We define an action as a change in a context. So, between the action and the signals there is a relation of $n : n$ (many to many).

3.2 *A Model for the Agents.* We represent each agent by a context, and its set of proprieties by a many-valued predicate language. Each proposition of it consists in two elements:

$a = (\Phi, \lambda)$

where Φ is a string which represents a well formed formula; and λ is a real in $[0, 1]$, which is associated to the string. This language includes the following rule:

$(a, \lambda_a), (a \to b, \lambda_{a\to b}) : (b, \Theta(\lambda_a, \lambda_{a\to b}))$ (1)

It is well known in Psychology that humans act to minimize the inconsistency of their believes. According to Gerla [7], we define the two propositions' inconsistency degree as the real returned by the inc_{ab} function.

$inc_{a,b} = min(\lambda_a, \lambda_b) if(\Phi_a \leftrightarrow \neg\Phi_b)$ (2)

In addition, we define the inconsistency degree of a proposition set as the maximum degree of inconsistency of two propositions that we obtain by the set of propositions and an inferential apparatus.

Our language will include these four operators: $Goal_x(\Psi, \lambda), Bel_x(\Psi, \lambda), K_x(\Psi, \lambda)$ and $CK_{xy}(\Psi, \lambda)$. We interpret $Goal_x(\Psi, \lambda)$, the agent x has the goal Ψ with degree λ. We interpret $Bel_x(\Psi, \lambda)$, the agent x believes Ψ with degree λ. We interpret $K_x(\Psi, \lambda)$, the agent x knows Ψ with degree λ.

The K operator has had many interpretations. Here we refer to K as true belief:

$K_x(\Phi, \lambda) \leftrightarrow (\Phi, \lambda) \wedge Bel_x(\Phi, \lambda)$ (3)

Many authors showed limitations in (3). According to [1], we use K in association with Bel. So, we consider valid the following:

$Bel_x(K_y(a), \lambda) \leftrightarrow Bel_x(a, \lambda) \wedge Bel_x(Bel_y(a), \lambda)$ (4)

By this use of K and Bel we model the reasoning of an agent that from the context of his beliefs about another agent derives beliefs on his own context. So, if x's belief context on y is associated with a certain inconsistency degree, and a believes that y's inconsistency degree could not be higher than a given value, it follows that at least one of x's beliefs about y is false.

We interpret $(CK_{x_n..x_n}(\Psi), \lambda)$, among the agents $x_1, ..., x_n$ it is common knowledge Ψ with degree λ. Now we introduce the concept of game. In Game Theory a game in normal form is represented as in (5):

$g = (1, ..., n, X_1, ..., X_n, M)$ (5)

where: $1, ..., n$ is the player set, $X_1, ..., X_n$ are a sets of moves, each move set represents the moves accessible to a certain player and M is a function which returns a set of results (one for each player) for each combination of moves played by all the players. In this model a game is defined as in (6):

$g = (1, ..., n, X_1, ..., X_n, M, U_1, ..., U_n)$ (6).

In (6) M represents an internal function of I, which receives as its argument a combination of moves for each player. The set $U_1, ..., U_n$ represents a set of utility functions, each utility function returning a real in $[0, 1]$ for each state of the world. We represent a game as a specification of a context as in Donato [5]. So, each game is represented by a set of our language's propositions.

By using the language described, we can define a particular fuzzy multi context. It consists in the following elements: $\{EmotStateSensInput, Games, BelSet, PastData,$ $\{assumeGame, upDateEmotionStatesSens, upDateBel\}$

Where $\{EmotStateSensInput, Games, BelSet, PastData\}$ is a set of contexts and $\{assumeGame,$ $upDateEmotionStatesSens, upDateBel\}$ is a set of bridge rule.

Before we state the context representations, it is appropriate to point out the convention whereby S represents the set of all possible state that an agent could assume, and s is a generic member of S.

Now we have all the elements to represent the agent. First, we describe the contexts, and then we'll describe the bridge rules.

3.3 *The Agent's Contexts.* We represent the agent's EmotStateSensInput by a set of formula of a propositional language [11]. $Games$ is the set of $BasicGames$, which are known by the agent, plus a set of $rules$ to build new games using the basic ones. We represent each element of the $BasicGames$ in a first order language. The $rules$ is a set of operators which given a couple of games returns a new games. $BelSet$ is the agent's beliefs set. Here we need a propositional language plus the operator described in 3.2. The $PastData$ represents a set of collected data on past cases. It collects information of the kind I was in the situation x_1, I have done the move m and then I was in the situation x_2.

3.4 The set of Agent Bridge Rules. The Agent's set of bridge rules consists in a set of multy contexts productions rules. Each one of them returns an action in a context depending from the degree with which is true a set of formulas belonging to different contexts.

In order to have a complete flexible system we would need bridge rules to update all the agent's contexts. So we would need four kind of bridge rules: $upDatePastData$, $upDateEmotionStatesSens$, $upDateBel$, $upDateGames$.

A rule of the kind $upDateBel$ is a rule, it makes the agent to change a believes in relation with the state of the agent's contexts. It corresponds to a function from S to $BelSet$.

The $assumeGame$ is a rule of the kind $upDateBel$. The assumeGame rule is a kind of rule from a state to a propositon of the kind the game x is going on.

A rule of the kind $upDatePastData$ is a rule, that depending from the state of the agent it makes a change in the collection of the past data stored in the agent database. It corresponds to a function from S to PastData. This rule is useful to make the agent to learn new information.

A rule of the kind $upDateEmotionStatesSens$ model an action (an action in the environment, or an observation, or a change in the emotional state) of the agent. It is a rule, which makes a change in the EmotionStatesSens depending from the agent's state.

The $upDateGames$ is a rule which allow the agent to add a new game in the set of the known basic game. It corresponds to a function from S to Games. The semantics of this rule is the learning of new meaning.

The purpose of this work is a system that makes interpretations.

(We don't need to model the learning.) The needed agent bridge rules are the system's rules A, B and C.

The rule A belongs to the kind $upDateEmotionStatesSens$. This rule model an action. We model it by the action function.

The $action$ function. The action function goes from I to I. It receives as input an interaction situation i and it returns as output another situation i. We could interpret i as a situation that precedes an action and i as the one which follows. In the model we suppose that each agent act in each context by its rule. This means that each chooses his local best, given his informational resources and his computational capabilities. The agents' choices are moves in games. According to each games, the effects of the actions could be internal or external changes. In the second case, the action is translated first into a signal, and then into a sensorial input for other agents.

The rule B belongs to the kind $upDateBel$. The kind of rule which make the agent to change its believes in relation with the state of the agent's contexts. As we said in section 3.2, a many-value predicative language represents the belief set. We assume a rule, which imposes that the inconsistency degree could not overcome a given value. If this degree is reached some beliefs on the context will be cut. The rule B erases all the proposition which degree is lower then the inc function, see (2).

We define *ruleB function* to model that rule. The ruleB function is defined from S to S.

The rule C belongs to the kind $assumeGame$, it is a subkind of $upDateBel$. Before of state this rule let's recall that in (6) we have defined a game g, and let's define $G*$ and $G_{portion}$.

Given the agent's state we define $G*$ as the closure of the $BasicGames$ set under the operators in $Games$. We interpret $G*$ as the set of all games that the agent could imagine. It is clear that $G*$ could not be represented in the extensive way.

The $G_{portion}$set. We define the $G_{portion}(s, a)$ set as the portion of $G*$ that the agent, which starts from a particular state s, will generate by a finite number of action a. It is clear that $G_{portion}$ is a sub set of $G*$. We interpret $G_{portion}$ as the set of hypotheses that the agent is going to evaluate. We represent $G_{portion}$ by a set of formulas of the language.

$G_{portion}$ function. Now we define the $G_{portion}$ function as the function that given the state s and the number of action a returns the set $G_{portion}(s, a)$.

The *identification function*. The identification function take as input the set of hypothesis $G_{portion}$ set and gives to each one of its elements a valuation according to the $PastData$ set [6].

By now, we use these definitions of interpretation and communicative interpretation. We consider an interpretation as a function which receives input an agent' state and returns in output another state in which there is, at least, one belief which indicates that a certain context is active. We consider a communicative interpretation as a specification of an interpretation. A communicative interpretation is an interpretation function, which returns the belief that a game is going on.

Now we can state that by the rule $assumeGame$ we want to model a communicative interpretation. Before to state the function which models the $assumeGame$ we define the function $basicInterpretation$.

The $basicInterpretation$ function. We define the basicInterpretation function by using a combination of identification function and $G_{portion}$function, as it follows.

basicInterpretation (s) s1=identification function($G_{portion}$ function(s,a),PastData) s1.c=0 $\rightarrow$ s1.=basicInterpretation1(s1)

Now we can define the $assumeGame$ function by using a combination of $basicInterpretation$ and of the rule B function, as it follows.

AssumeGame (s) s1=ruleB function(basicInterpretation(s)) s1.c=0 $\rightarrow$ 1=AssumeGame(s1)

3.5 ***The Agent's Loop.*** The loop is a fundamental parts of any agent model. Given the rule and the facts of each context it consists in the agent's inferential apparatus. In our case, we use the set of agent bridge rules in order to model the agent's loop. Basically, the agent's loop consists in the three rules: rule A, rule B and rule C. We could interpret rule A as perception/action (as we state, in this model, a particular kind of action is a perception), rule B as believerevision, and rule C as communicative interpretation.

4 Conclusions

The main purpose of this article is to point out, the symbolic and the intersubjective approaches are not incompatibles. To this end, we have presented an intersubjective symbolic model of the interaction. The idea of intersubjectivity comes from Wittgenstein's work, and in particular to the notion of Wittgenstein's linguistic game. We could summarize its main claim as: to understand communicative actions we have to use social structures. The dominant AI approach to interaction does not respect this claim. They define an interpretation as function from an external signal to a private internal state. We refuse this solipsisitic choice. In this work, we define an in interpretetion as a function from a signal to an action in an intersubjective structure. In the described system, we formalise these structures by games, and we represent games as formulas of a logical language. As result of our work, we have a system which reminds quite close Kurt Lewin's interpretation of the Mind. We hope this work will contribute to bring AI, cultural psychology, game theory, and ethnomethodology to have a better communication.

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