MODELING DIALOGUE BY FUNCTIONAL SUBCATEGORIZATION

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Abstract

In this paper we present a dialogue model which has as its main goal to place in context the utterance generated by the speaker. The dialogue model considers that an intervention generates one or more ilocutive acts which are handled as functions. These functions subcategorize to or are subcategorized by other functions in the dialogue.

The model uses an exchange schema with the purpose of expressing the different functional subcategorizations. These schemas have properties close to the semantic forms of the verbs in a lexical-functional context.

1 INTRODUCTION

In task-oriented dialogues two speakers work in cooperation with the purpose of carrying out a plan. This type of interaction has a start and a development structured by the restrictions of space, time, transaction object and role of the participants.

A number of researchers [Grosz and Sidner, 86; Litman and Allen, 87; Ramshaw, 91; Lambert and Carberry, 92] have suggested that a coherent discourse consists of segments that are related to one another through some type of structuring relation. Our dialogue model tries to capture the goal-oriented nature of discourse, identifing the discourse structure by providing the details of a computational mechanism for recognizing the structural relationships.

The model enables the incremental recognition of communicative goals using rewriting rules and functional equations. The grammar constructs the structural tree capturing the dialogical functions of the discourse using functional subcategorization. The subcategorization process improves on previous approaches [Ferrary et al., 88; Bilage, 91; Jönsson, 91], increasing the expresive power of the traditional dialogue models by modeling the relationships among the communicative actions enabling the task of connecting discourse.

The different parts of the system have been implemented using a blackboard architecture. The process starts obtaining the f-structure associated to the intervention making use of a lexical-functional grammar [Abaitua et al., 91]. In a second phase the f-structure is refined providing the correct explanation, essentially it solves the verbal interpretation and obtains referential information. Then, the planner and/or the dialogue module start to work.

In the remainder of this paper, we will present our dialogue model in a top-down manner. Firstly, we show the exchange structure adopted and the subcategorization process using two samples. Then, we explain the retroactive and proactive nature of the interaction and we conclude by presenting two kinds of special interventions, the complex and compound interventions.

2 EXCHANGE STRUCTURE

We assign to the constituents of the exchange level initiative and reactive ilocutive functions. These functions qualify constituents which are in the same level of structuration. The initiative functions are assigned to the directrice interventions of the exchange. The reactive functions constitute the generic class of the answers and they try to satisfy the obligations assumed for the interpretation of the initiative functions.

Analyzing the corpus that we dispose we have detected the following initiative functions : F_{req}, $F_{req\text{-}prel}$[1], $F_{req\text{-}aux}$, $F_{req\text{-}fic}$, $F_{qinform}$, F_{qref} and F_{qif}. F_{req} is a function associated with a petition of achievement a physical action. $F_{qinform}$ inquires information about the plan in progress. F_{qref} and F_{qif} demand referential and polar information.

The above initiative functions are completed with the following reactive functions : $F_{informreq}$, F_{inform}, F_{infref} and F_{infif}.

We assign to the initiative functions, with directrice characteristics, one exchange schema with similar performance to the semantic forms of the verbs in a lexical-functional context. This exchange schema will be identified from now with the word SCHEMA. An schema specification will exhibit the subcategorizations detected inside an exchange. Therefore, an exchange with an initiative function of type $F_{qinform}$, inside which a nested exchange has been produced, will have the following schematic representation :

$$SCHEMA = \text{`}F_{qinform}\#<(\uparrow E_{comp})(\uparrow F_{inform})>\text{'}$$

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[1] $F_{req\text{-}prel}$, $F_{req\text{-}aux}$ and $F_{req\text{-}fic}$ are functions subcategorized by F_{req} and represent preliminaries, auxiliar forms of the request and fictitious executions of actions.

SCHEMA = '<([*Sugcategorized_by*]) > # F_x #

<([*Sugcategorize_to*])>'

Just like in a lexical-functional grammar, the initiative function $F_{qinform}$ subcategorizes to the reactive function F_{inform} and to a subexchange identified by E_{comp}. This subexchange has, at the same time, a specific initiative function which subcategorizes to the appropriate reactive function and which is subcategorized by the $F_{qinform}$ function. One example of dialogue sequence where this schema could be applied is the following :

S_1.- How does it modify the camera's diafragm ? **($F_{qinform}$)**

S_2.- Do you know where is the key for modifying it ? **(F_{qif})**

S_1.- Yes, in the left part of the camera **(F_{infif} + F_{infref})**

S_2.- Ok, then press the F3 buttom and move the key towards the left **(F_{inform})**

In the model which we are going to present both the exchange structure and the intervention structure are going to be definied using rewriting rules. The tree nodes will be enrichied with functional specifications just like a lexical-functional grammar. These functional specifications will reference to the initiative and reactive functions which are going to appear in the conversation.

The grammar initialy will have the following rules :

(1) D --> E_1..... E_i .....E_n

($\uparrow$ EF_1) = $\downarrow$ ($\uparrow$ EF_i) = $\downarrow$ ($\uparrow$ EF_n) = $\downarrow$

D represents a dialogue, E_i the exchange i and EF_i the functional specification of the exchange i.

(2) E_i -> I_1 I_2 (I_3)

($\uparrow$ F_x) = $\downarrow$ ($\uparrow$ F_y) = $\downarrow$

I_j represents the intervention j of exchange E_i.

Both F_x and F_y represent speech acts of the form F(p). That is to say, every node I_i will not reflect only the referential and predicative aspect of the interation but also will express the ilocutive force associated to every speech act. A single exchange will be constituted for an initiative intervention and we could suggest nuclear to the exchange, an initiative-reactive intervention and optionaly for a closure reactive intervention of the exchange.

The functions F_x and F_y associated with every constituent will be instantiated for some of the initiative and reactive functions introduced before.

The rule (2) formulated above handles balanced conversational sequences, that is to say, sequences of the following form :

$S_1(I_1)$.- Please, change the exposure mode.

$S_2(I_2)$.- I changed it already and I have left it in PROGRAM.

$S_1(I_{3-1})$.- Ok, let us continue, how can I change the speed ?

$S_2(I_2)$.- Press the key XY23 and move the lever.

The structural-functional tree which would correspond to this dialogue piece would be the one showed in Fig. 1. Structuraly the dialogue fragment would be constituted by two exchanges which inform about the physical actions performed by the speaker and which are connected with a high level task.

Let us imagine that instead of the previous dialogue piece we produce another one modified a little :

$S_1(I_1)$.- Please, change the exposure mode.

$S_2(I'_1)$.- Sorry, how do I change it ?

$S_1(I'_2)$.- Yes, press the buttom MODE and move the lever on the right side.

$S_2(I_2)$.- I changed it already and I have left it in PROGRAM.

$S_1(I_3)$.- Ok, let us continue.....

This second dialogue illustrates a very common phenomena, the speaker departs, momentarily, from the main direction of the conversation, in order to start a secondary exchange which, in most cases, will have a subgoal to be achieved, and then returns to the main axis of the conversation.

In order to manager these cases we propose a rule like this :

(3) E_i --> I_1 E'_i I_2

$\uparrow = \downarrow$ ($\uparrow$ E_{comp}) = $\downarrow$ ($\uparrow$ F_y) = $\downarrow$

Fig. 2 shows the dialogue structure obtained by means of the aplication of the above rule. We associate the schema 2.a to an exchange which has, like initiative intervention, a request function of achievement physical actions. At the same time, this function subcategorizes to an subordinate exchange - E_{comp}- and a reactive intervention.

We emphasize that the subordinate exchange E_{comp} has a retroactive nature so that it would not appear at the moment of the initial formulation of the schema.

The schema 2.b is a bit different from the standard notation of a lexical-functional grammar, it specifies an element in the left hand side of the nuclear function. This element will be at the same time the nuclear function of another exchange and reflects the subcategorization that exists between this element and the nuclear constituent of the subordinate exchange.

The subexchange E'_i especified above like E'_i --> I'_1 I'_2, can have, of course, nested dialogues defined with the rule E'_i--> I'_1 (E''_i) I'_2. In our corpus we do not find subdialogues with more than three nested levels very often.

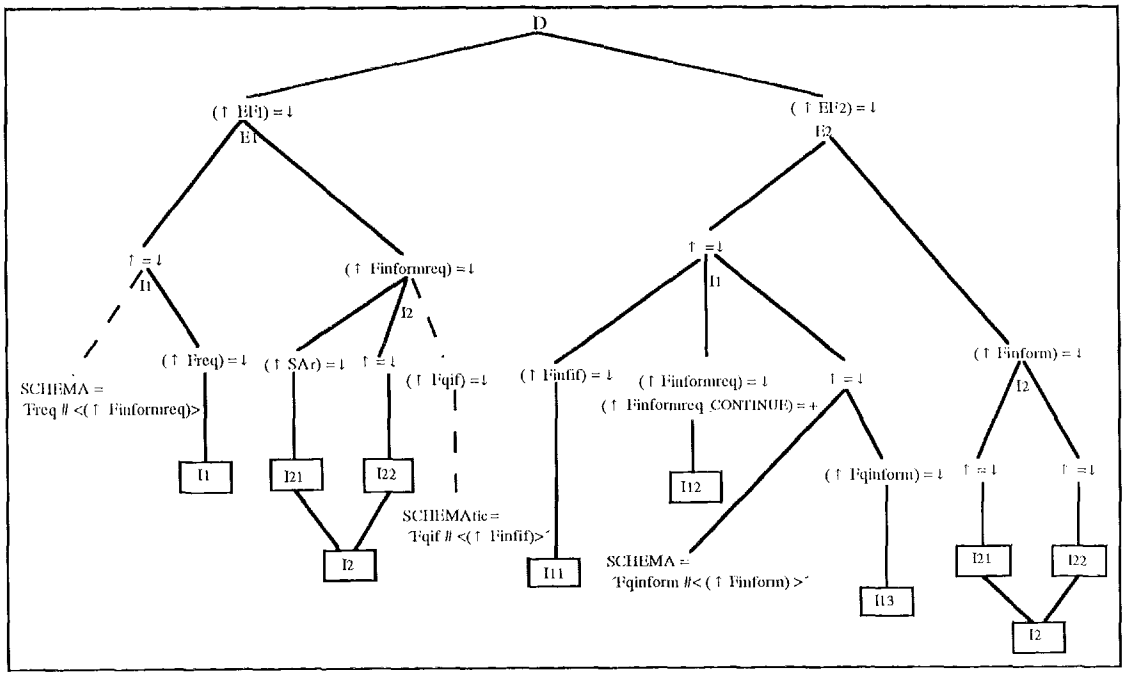

Fig. 1 Structural-functional tree of a balanced conversational sequence

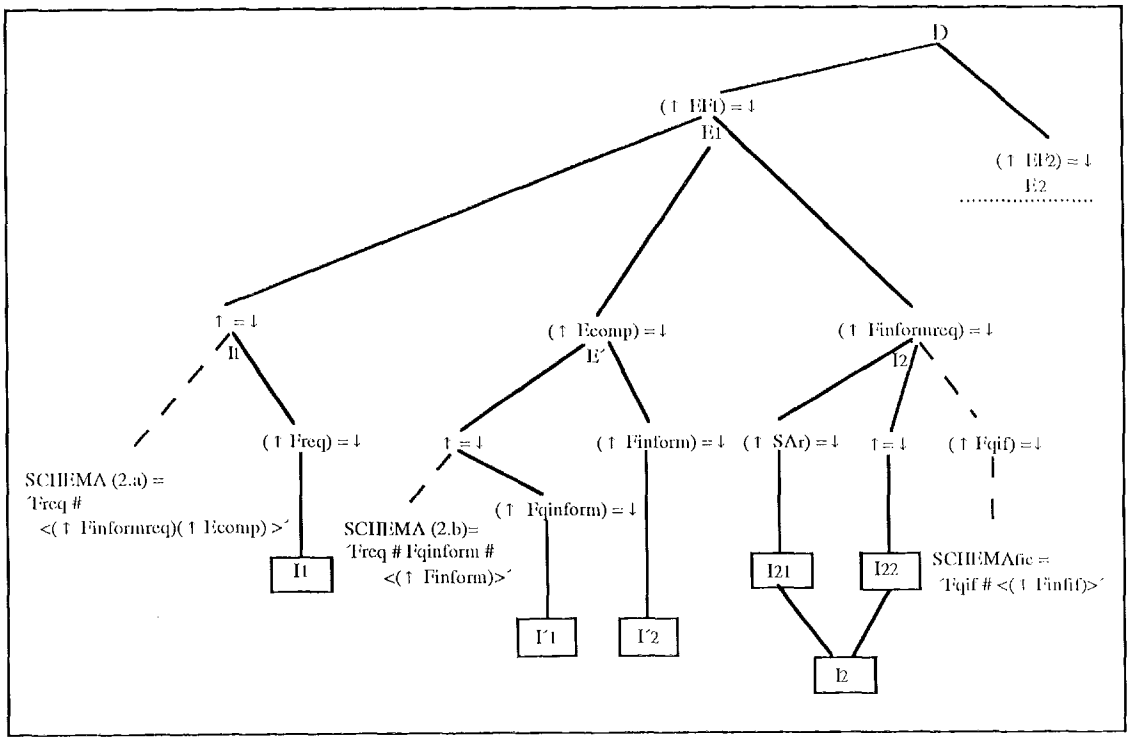

Fig. 2 Dialogue structure with subordinate exchanges

3 PROACTIVE AND REACTIVE FEATURES IN THE INTERVENTION

An intervention will be composed by a main act that we will designate director act, preceded and/or followed by optional subordinate acts. The director act is the speech act that provides the general sense of the intervention, that is to say, its ilocutive force.

In all intervention the interactive functions will be expressed using the proactive or retroactive features that we will associate to the intervention.

The following rules define the structure of an intervention:

$$I_i \text{ --> } (X^*) \quad I^D \quad (X^*)$$
$$(\uparrow SA)_c = + \quad \uparrow = \downarrow \quad (\uparrow SA)_c = +$$
$$X \text{ --> } \{ I_{pi} , I_{ri} \}$$
$$(\uparrow SA_p) = \downarrow \quad (\uparrow SA_r) = \downarrow$$

The first rule defines the hierarchical relation that exists between the director act (I^D) and its subordinate acts constrainted by functional equations. The second rule identifies the subordinate act like proactive or retroactive.

3.1 Complex interventions and compound interventions

In most cases, the reactive and proactive features of the subordinate acts are not related to the director act of the intervention where they appear. In these cases the subordinate act must find its director act in the dialogue sequence, basicaly before, but sometimes it must wait for the next interventions for its subcategorization.

The presence of this phenomena creates the necessity to extend the original model with the inclusion of mechanisms which enable to deal with another two new types of interventions: the complex interventions and the compound interventions.

The complex interventions are constituted of two or more subinterventions with a relation of local domain, that is to say, the subinterventions make reference to the initiative function of the exchange more immediate.

These interventions will have the following formulation in the model :

$$E \text{ --> } I_1 \quad I_x$$
$$(\uparrow F_1) = \downarrow \quad (\uparrow I_{compl}) = \downarrow$$
$$I_x \text{ --> } I_{x1} \quad I_{x2}$$
$$(\uparrow F_{x1}) = \downarrow \quad (\uparrow F_{x2}) = \downarrow$$

The schema assigned to the exchange inside of which it is the complex intervention will be the following :

$$SCHEMA = 'F_1 \# < \{(\uparrow F_{x1}) (\uparrow F_{x2}) \} (\uparrow F_{reac}) >'$$

F_1 subcategorizes to F_{reac} using the initiative function (F_{x2}) of the complex intervention.

The compound interventions are constituted of two or more subinterventions too, between them there is a relation of non local domain. In the cases of proactive movement the domain nature will remain defined a posteriori.

The compound interventions will have the following formulation :

$$E \text{ --> } I_1 \quad I_y$$
$$(\uparrow F_1) = \downarrow \quad (\uparrow I_{comp}) = \downarrow$$
$$I_y \text{ --> } I_{y1} \quad I_{y2}$$
$$(\uparrow F_{y1}) = \downarrow \quad (\uparrow F_{y2}) = \downarrow$$
$$\{ (\downarrow = \Downarrow), (\uparrow = \Uparrow) \}$$

The schema assigned to this exchange will be the following :

$$SCHEMA = 'F_1 \# < (\uparrow F_{y1}) > (\uparrow F_{y2})'$$

The function F_{y2} is subcategorized by the function F_1 but does not support thematic relations with it. These functions will be reactives and will have non local domain or proactives which produce a thematic rupture with the initiative function F_1.

We illustrate all this with the following dialogue fragment :

S_1.- Now I do not see anything
S_2.- Please, press the shooter half way.
S_1.- Where is it ?
S_2.- Close to the screen, a red buttom do you see ?
S_1.- Yes, yes symbols appear but I do not understand them.

How we can see in Fig. 3 the subordinate exchange E_{comp} generates a complex intervention like a reaction to the nuclear initiative function of the exchange. This complex intervention is composed of two subinterventions of reactive and initiative nature . This fact makes them both appear between curly-braces pointing out that we are treating the same intervention. The presence of the initiative function F_{qif} generates the schema 3.3 where the initiative function is subcategorized by the former initiative function (F_{qref}) and subcategorizes, at the same time, to the reactive function (F_{infif}) that appear subcategorized in the former schema. This function represents an expectation generated for F_{qif} in 3.2 and an achievement in 3.3.

The schema 3.3 is related to a compound intervention where one of the subinterventions plays a reactive role associated with the former intervention. The next subintervention, reactive too, is non local and therefore is not subcategorized for the nuclear function of the schema 3.3. This subintervention is subcategorized for the function F_{req} of the schema 3.1. The metavariables $\Downarrow$ and $\Uparrow$ show the relation of non local domain that exists between both functions.

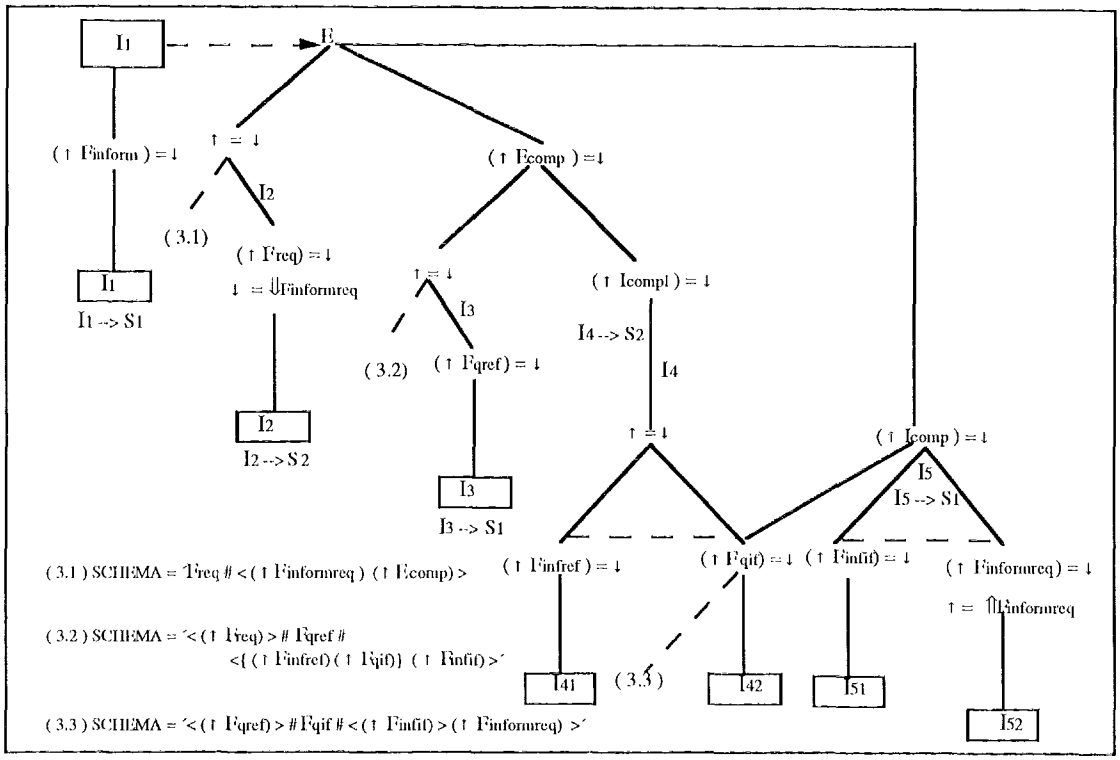

Fig. 3 Complex and compound interventions

4 CONCLUSIONS

We have presented a dialogue model that uses functional subcategorization for recognizing the structural relationships of the discourse. The subcategorization process applies a structural schema to every exchange producing a functional definition with properties close to the semantic forms of the verbs in a lexical-functional grammar.

The model enables us to handle subordinate exchanges capturing the dependencies that exist among the ilocutive functions relating the main function of the exchange to the initiative function of the subordinate exchange. The complex and compound interventions make use of the same mechanism of subcategorization using the proactive and retroactive features of the interventions.

The parser has been written in Prolog with a bottom-up strategie. The interface between the blackboard and the different Knowledge Bases has been implemented in Common Lisp. The control mechanism uses the scheduling package of Knowledge Craft.

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