THE STRUCTURE OF COMMUNICATIVE CONTEXT OF DIALOGUE INTERACTION

A.S. Narin'yani, O.P. Simonova

AI Laboratory, Computer Center,
Siberian Division of the USSR Ac.Sci.,
Novosibirsk 630090, USSR

ABSTRACT

We propose a draft scheme of the model formalizing the structure of communicative context in dialogue interaction. The relationships between the interacting partners are considered as system of three automata representing the partners of the dialogue and environment.

The communicative competence of the partners is defined by
- the set M of all propositions reflecting the possible states of the three automata within the model;
- the set K of "contracts" representing all kinds of human-to-human relationships (social, interpersonal, professional, etc.) which include fixation of particular roles for the partners;
- the set T of possible topics related to given "contract ".

The authors believe the system of the notions presented may be used as a basis for forming the communicative component in the dialogue system.

1. INTRODUCTORY REMARKS

The elaboration of advanced user-computer dialogue systems requires the communication laws to be investigated and formalized. This domain of research has not yet been officially acknowledged as a part of computational linguistics. However, developing the formal models of speech interaction requires to take into account not only linguistic but communicative competence also. That is necessary for creating natural-language systems as well as any complicated system of "natural" dialogue, and especially important in view of constructing new generation computers intended for mass non-programming users.

We propose here a draft scheme of the model formalizing the structure of communicative context in dialogue interaction. The relationships between the interacting partners are considered as a system of three automata. Two of them represent the agents of the dialogue and the third one is a model of the world including the environment of interaction and other agents if they participate. The automaton-agent is the central component of the communicative competence model. We divide memory of each agent into extracommunicative and communicative parts. The latter directly concerns with the relationships between the agents in projection onto the interaction process.

Two restrictions have been accepted to simplify the model.
(a) Communicative competences of both the agents, i.e. their beliefs about communication laws and actual state of their relations are identical just up to current communicative act (CA) because the contents of the act (including the communicative contents) at the moment of its producing is known to the speaker only.
(b) Receiver extracts from CA just the same information the speaker implies.

2. INITIAL NOTIONS

We shall introduce necessary notions and notations. Let {M} be a set of all propositions reflecting the possible states of the three automata within the model, and M be a memory representing the agents' mutually coordinated beliefs about the world. State of M at moment τ (i.e. M_τ) is a consistent subset of propositions from {M}, each of which being characterized by index of certainty.

The machinery of interaction between the agents is dominated by a system of c o n t r a c t s. Here contracts represent all kinds of human-to-human relationships (social, interpersonal, business, etc.) For example, "chief-subordinate", "official-client", "friends", "married couple", "patron-ward", etc.

Contract is represented with a tuple
k, $\overline{X}$, $\overline{Y}$, Cond, Cond-Act, Cond-Des, T,
where
k is a name of contract;
$\overline{X}$ and $\overline{Y}$ are roles of partners X and Y in the contract;
Cond, Cond-Act and Cond-Des are consistent subsets of propositions from {M}, called general conditions, conditions of activation and conditions of desactivation of the contract, respectively;
T is a set of interaction topics related to given contract.

The interaction between the agents is realized by means of communicative acts (CA), in particular, of speech acts. Every CA is characterized with roles (author-receiver), aim, topic and value of phase function indicating the relation between CA and the topic (CA can be initiating, continuing, closing and re-initiating in respect to its topic). A subsequence of coherent communicative acts connected with the same topic is called a t-i n t e r a c t-i n g. Discourse is considered as a system of embedded t-interactings. The simplest t-interacting

may consist of a single CA which simultaneously initiates and closes its own topic (for example, CA requiring no reaction from the receiver). Topic is represented here by the following tuple

t, $\overline{X}$, $\overline{Y}$, Cond, Aim, Scr, Cnsq,

where

t is a name of topic;

$\overline{X}$, $\overline{Y}$ and Cond have the same meaning as for contract in the above definition;

Scr is a set of scripts of t-interactings which realize the topic t (a script is either a single CA being the simplest t-interacting mentioned above or a chain of correlated embedded subtopics, respectively); the scripts in Scr may be just listed or/and specified by means of a formal generative procedure;

Cnsq is a set of all possible consequences of closing t, i.e. a set of modifications of the memory M resulting from t-interactings which realize the potential scripts of Scr;

Aim is a subset of Cnsq which conventionally is considered as the aim of agent initiating the topic t.

Initiating some topic t the agent chooses some script from Scr he plans to realize; in general case a script allows several possible continuations at every intermediate point of its realization, one of these continuations corresponds to the script the agent plans to realize at the given moment.

3. COMMUNICATIVE CONTEXT

Thus the communicative competence of the agents is defined by the set {M} of propositions, the set {K} of contracts and the set {T} of topics possible for X and Y. To demonstrate the functioning of our model we shall consider the component of M related directly to the process of communication. This component being called Communicative Context (CC), includes:

- a set T_τ of current topics, i.e. the topics initiated before a moment τ and not closed yet, to each topic $t \in T$ current script of its realization is put in correspondence. The topics belonging to T_τ are hierarchically embedded so that the topic t is embedded into the topic t' (or t' is on higher level than t) if t is initiated according to the current script of t'; a current topic/script which $CA_{\tau-1}$ belongs to,will be referred as actual topic/script;
- a set K_τ of contracts being in the activated state for the agent at the moment τ;
- a subset $^+K_t \subseteq K_\tau$ of contracts related to the topics included in T_τ; i.e. the contracts immediately related to the contents of the interaction.

The transformation of K_τ is defined by the following rules (for each $k \in K$);

(a) if Cond-Act (M_τ) and $k \in K_\tau$ is true, then the contract k is included into $K_{\tau+1}$;

(b) if $(k \in K_\tau)\&(Cond_k(M_\tau)=false)$, i.e. conditions of the contract k are not fulfilled, the contract k is excluded from $K_{\tau+1}$;

(c) if $Cond\text{-}Des_k(M_\tau)\&k \in K_\tau$ is true, the contract k is excluded from $K_{\tau+1}$; it does not mean that $Cond\text{-}Des_k(M_\tau) \rightarrow NO\ Cond_k(M_\tau)$ takes place.

The rules (a) and (b) require $Cond\text{-}Act_k(M_\tau) \rightarrow \rightarrow Cond_k(M_\tau)$.

For the contracts in K a system of relations can be defined, for example: contracts k1 and k2 are mutually incompatible if $Cond_{k1}\&Cond_{k2}$=false; k1 is $\ddagger$incompatible with k2 if $(k2 \in {}^+K_\tau \vee Cond_{k2}(M_\tau)) \rightarrow \rightarrow (Cond\text{-}Des_{k1}(M_\tau) \vee NO\ Cond_{k1})$; k1 implies k2 if $(Cond_{k1} \vee Cond\text{-}Act_{k1}) \rightarrow Cond\text{-}Act_{k2}$ or $k1 \in K_t \rightarrow Cond\text{-}Act_{k2}(M_\tau)$.

The main scheme of the considered machinery of communication can be described as follows. A current state M_τ causes agent (X) to set some goal; X forms a plan to achieve the goal and begins to realize it. Some step of X's plan demands to involve the partner Y: to perform definite action or to accept some proposition as valid or to provide information needed, etc. To get this result is the aim of X at the given step of this plan. To gain the aim, X should choose an appropriate topic (one of the topics with this aim). In the simplest case it is possible to use just the next topic t in the script of the higher level topic with an aim being more general in the X's plan than the current one. In this situation initiating the subtopic t produces minimal modification of CC (which is adding t to T) and does not modify the set K of the activated contracts and its subset ^+K. In more complex cases to initiate an appropriate topic t it is necessary to include in ^+K one of contracts from $K/{}^+K$ or even to activate some new contract k', i.e. to include k' in K. Closing a current topic t may produce some consequences from $Cnsq_t$ with the corresponding modification of M which can lead to

- the end of communication,
- a new goal for X and/or Y,
- moving to the next subgoal in the current plan.

In the next section we shall consider the spectrum of possible situations related with realization of current CA.

4. MODELLING THE PROCESS

Each current act CA_τ may be initiating, continuing or closing with respect to embedding topic t belonging to T_τ.

The initiation of the topic t by CA_τ may correspond to three different types of situations: "normal order", "interruption with return", and "interruption without return".

(a) Normal order covers the following situations:

- the previous act $CA_{\tau-1}$ has closed the topic t', and the topic t is the next in the script the topic t' belongs to; if t' closes simultaneously several consecutively embedded topics, then t is the next topic of the script of the lowest unclosed topic;
- $CA_{\tau-1}$ has closed one of the highest-level topics belonging to $T_{\tau-1}$, then (i) t belongs to one of the contracts from $^+K_{\tau-1}$ or (ii) the contract k has been activated, but not included into $^+K_{\tau-1}$ (i.e. $k \in K_\tau/{}^+K_\tau$), or (iii) t activates a new contract $k \in \{K\}$ and includes it into K_τ and $^+K_\tau$ (that is possible if the initiation of t

at moment τ leads to fulfillment Cond-Act$_k(M_\tau)$;
(b) Interruption with return covers the following situations: the topic of the act $CA_{\tau-1}$ has not been closed yet, but t is another topic of the same or another contract; if a change of topic is marked by "interruption with return", then this "deviation" is necessary either (i) for continuing the interrupted topic (return after some previous interruption), or (ii) for the realization of the high-priority aim related to the new topic t;
(c) interruption without return covers the situations described in (b) but without the "return" mark as well as the following situation: the topic of the act $CA_{\tau-1}$ is not closed and t is the next topic of the same or higher-level script; the interruption without return usually means by default that the interrupted topic is considered to be closed with success or failure depending on the interrupted and new topics).

The act CA_τ continued actual topic t may be realized in situations related to the normal order or to the return after interruption.
(a) normal order means that CA_τ continues the topic of the previous act $CA_{\tau-1}$;
(b) return after interruption means that CA_τ continues the topic remained to be unclosed under "the interruption with return". The topic t being closed by the act CA_τ, some or all modifications listed in $Cnsq_t$ take place in the memory M. These modifications reflected in $M_{\tau+1}$ can cause the following situations:
(a) $K_{\tau+1} = K_\tau$, i.e. no contracts are activated or desactivated, the current script of the actual topic and higher-level topics are not alternated;
(b) $K_{\tau+1} = K_\tau$, but one/some of the current scripts are alternated;
(c) contract k is closed (i.e. Cond-Des$_k(M_{\tau+1})$ = truth);
(d) other contracts are closed and/or activated.

The work presented is the part of the integral project on the language interaction model being elaborated in our laboratory.

The authors believe the system of the notions presented may be used as a basis for forming the communicative component in the dialogue systems including the natural-language interfaces.

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