Using knowledge to model cooperative information retrieval dialogues

Paulo Quaresma and Irene Pimenta Rodrigues
Departamento de Informática,
Universidade de Évora,
7000 Évora, Portugal
{pq,ipr}@di.uevora.pt

June 8, 2000

1 Introduction

In this paper we present some aspects of a web cooperative information retrieval system in the law domain, which allows multimodal dialogues including natural language sentences.

Our system is able to keep the context of the user interaction and it is able to cooperatively supply suggestions for further refinement of the user query.

The refinement process is based on the domain knowledge and the ability to compute clusters of documents associating a keyword (from a concept taxonomy with 6000 expressions) to each cluster.

In order to perform a cooperative dialog with the user, we would like:

- To infer what are the user intentions with the queries. When a user asks for documents with a particular keyword, usually he is interested in documents that may not have that keyword and he is not interested in all documents with that keyword.
- To supply pertinent answers or questions as a reply to a user question. The system must supply some information on the set of documents selected by the user query in order to help him in the refinement of his query.

And we need:

- To record the previous user interaction with the system (user questions and the system answers). This record will play the role of a dialogue structure. It provides the context of sentences (questions and answers), allowing the system to solve some discourse phenomena such as anaphoras and ellipses.
- To obtain new partitions (clusters) of the set of documents that the user selected with his query(ies).
- To use domain knowledge whenever is possible.

2 Dialogues

Dialogues in the context of information retrieval systems are different from traditional dialogues in computational linguistics [LA87, Pol90, CCC98, CL99, MP93, Loc98] because our user normally does not have a plan to execute, he actually does not have a precise goal such as: 'go to Boston' or 'phone to Mary'. Our users may want to see some documents, but they do not know which particular documents. The function of our dialogue system is to help a user defining his goal. In order to accomplish this purpose our system uses the user interventions and some knowledge from the text database.

After a user query the system may:

Show the set of documents selected by the query. Since our information retrieval system is boolean, the documents that are selected are just those that match the query.

Present a set of keywords that may help the user to refine his query. In order to build a set of keywords the system may build groups of documents (clusters) from the initial set selected by the user query. The groups of documents are disjoint, i.e., there are no document that belongs to more then one group.

Present a set of concepts that may help the user to refine his query. In cases where the system as knowledge about some of the documents subject it is possible to build groups of documents using that knowledge, and to provide the user concepts for refining its query.

Explain the user why his query does not select any document, providing suggestions for other queries. Most information retrieval system assume that the user will never get to a dead-end with its queries, so they relax on the meaning of a query by using non boolean retrieval systems. These systems are appropriate for general Web searches, but for a system that intends to control the search we think that a boolean system is best suited.

3 Example

Suppose that the user his a retired fireman that has saved a child from drowning in a river during his holidays putting his life at risk. Since he has caught a pneumonia as a consequence, he wants to know if he can get a pension for relevant services to his country.

User - Q1: Documents about pensions for relevant services?

System - Q2: There are 243 documents, listed in the right frame. For further refinement you may choose one (or none) option in each column:

Pensions that were:
given
or refused

Pensions for:
militaries
or civilians

Documents with keyword:
drowning
or medal
or in duty
or ...

User - Q3: chooses: *civilians* and *drowning.*

System - Q4: There are 45 documents, listed in the right frame. For further refinement you may choose one (or none) option in each column:

Documents with keyword:
death
or accident
or ...

User - Q5: Documents where there was a drowning in a river.

System - Q6: Since there are 13 documents of the 45 above that match the concept, I've listed them in the usual frame. For further refinement you may choose one (or none) option in each column:

Documents with keyword:
car crash
or bridge
or ...

User - Q7: Where there was someone swimming?

System - Q8: Since there are no documents of the 13 above that match your new constraint. I assume that you want that your query refines Q3, i.e. you are looking for documents with the concept swimming, and drowning and pensions for relevant services for civilians. Do you want to see these documents?

User - Q9: Yes.

4 Knowledge representation

Our system uses four levels of knowledge in order to be cooperative: Interaction, Domain, Information Retrieval and Text:

- The interaction level is responsible for the dialogue management. This includes the ability of the system to infer user intentions and attitudes and the ability to represent the dialogue sentences in a dialogue structure in order to obtain the semantic representation of the dialogue.

- The domain level includes knowledge about the text domain and it has rules encoding that knowledge. For instance, in the law field it is necessary to represent under which conditions a pension for relevant services may be given to someone; those pensions are usually attributed to militaries or to civilians such as firemen, doctors, and nurses.

- The Information Retrieval Level includes knowledge about what we should expect to find in texts about a subject, for instance that in texts about pensions for relevant services, the pension may be attributed or refused.

- The Text Level has knowledge about the words and sequence of words that are in each text of the knowledge base.

5 Dialogue structure

The system builds the dialogue structure to record both user and system questions and answers. This structure is used to compute the meaning of an user query and to allow the user to return to a previous point of the dialogue and to build a new branch from there.

The Dialogue structure is made of segments that group sets of sentences (user and system sentences). The dialogue segments have precise inheritance rules defining how segments heritage their attributes from the attributes of their sentences. The dialogue structure also enables the system to recognise and to generate pertinent discourse phenomena such as anaphoric references.

We have the following kind of segments to build a dialogue structure:
Basic — has 2 arguments: Speaker;Sentence Semantic Representation
New — has 2 arguments: Dialogue Structure; Dialogue Structure. This Dialogue Structure inherits their attributes from their second argument. Ex: New([],basic(User,Q1))
Specify — has 2 arguments: Dialogue Structure; Dialogue Structure. This Dialogue structure inherits their attributes from both dialogues structure.
Repair — has 2 arguments:Dialogue Structure; Dialogue Structure. This Dialogue structure inherits their attributes from the second dialogue structure

Rules to build the discourse structure: Given sentence(S1,Speaker) where S1 is the first sentence semantic representation, the update of the new sentence dialogue is:
s(basic(Speaker,S1)).

This fact gives rise to the update of the new Dialogue Structure according to the above rules:

1) ds(specify(O_{ds},D_s)) $\leftarrow$
ds(O_{ds})/past, s(Sp,D_s)/now,
bel(Sp,specify(O_{ds},D_s)/now.

2) ds(new(O_{ds},D_s)) $\leftarrow$
ds(O_{ds})/past, s(Sp,D_s)/now,
bel(Sp,new(ds(O_{ds},D_s))/now.

3) ds(repair(O_{ds},D_s) $\leftarrow$
ds(O_{ds})/past, s(Sp,D_s)/now,
bel(Sp,repair(O_{ds},D_s)/now.

These 3 rules encode that the new discourse structure is a structure that includes the semantics of the new sentence and that the systems is able to infer that at this point of the dialogue the speaker believes in that structure. The conditions for speaker beliefs will be presented later, but as it can be seen from discourse structure of dialogue 1 in figure 1: the system normally intends to specify the user previous sentence; and there are preferences for assuming that the user intends to specify the previous dialogue structure.

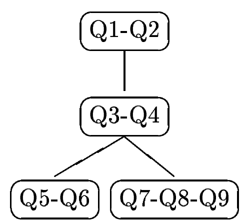

Figure 1: Dialogue Structure for Dialogue 1

The structure of dialogue 1 in figure 1 was built using these rules and it represents the dialogue structure after utterance Q9. The tree in the figure is the representation of following terms, where spf for specify.

ds(new(Q1))/t_0.
ds(spf(new(Q1),Q2))/t_1.
ds(spf(ds(D)/t_1,Q3))/t_2.
ds(spf(ds(D)/t_1,spf(Q3,Q4)))/t_3.
ds(spf(ds(D)/t_3,Q5))/t_4.
ds(spf(ds(D)/t_3,spf(Q5,Q6)))/t_5.
ds(spf(ds(D)/t_3,Q7))/t_6.
ds(spf(ds(D)/t_6,spf(Q7,Q8)))/t_7.
ds(spf(ds(D)/t_6,spf(Q7,spf(Q8,Q9))))/t_8.

The system displays a representation of the dialogue similar to the one in figure 1, but without the system interventions in order to help the user to keep in mind the dialogue context. Moreover, our system allows the user to select a node in the tree for defining the context of his next query. The node selection is translated into a user belief in a discourse structure for the next utterance.

6 Inference of user Intentions

In order to be collaborative our system needs to model user attitudes (intentions and beliefs). This task is also achieved through the use of logic programming framework rules and the dynamic LP semantics [PQ98].

The system mental state is represented by an extended logic program that can be decomposed in several modules [QL95]:

— Description of the effects and the pre-conditions of the speech acts in terms of beliefs and intentions;

— Definition of behaviour rules that define how the attitudes are related and how they are transferred between the users and the system (cooperatively).

For instance, the rule which describes the effect of an inform and a request speech act from the point of view of the receptor (assuming cooperative agents) is:

bel(A,bel(B,P)) $\leftarrow$
    inform(B,A,P)/bef.
bel(A,int(B,Action)) $\leftarrow$
    request(B,A,Action)/bef.

In order to represent collaborative behaviour it is necessary to model how information is transferred from the different agents:

bel(A,P) $\leftarrow$
    bel(A,bel(B,P))/now,
    (not bel(A,P))/bef.
int(A,Action) $\leftarrow$
    bel(A,int(B,Action))/now,
    (not neg int(A,Action))/bef.

These two rules allow beliefs and intentions to be transferred between agents if they are not inconsistent with the previous mental state (neg stands for the explicit negation and not stands for the negation by omission).

After each event (for instance a user question) the agents' model needs to be updated with the description of the event that occurred. The dialogue system recognises the speech act and it constructs the associated speech act (request or inform). The speech act will be used to update the logic program in order to obtain a new model. Using this new model it is possible to obtain the intentions of the system.

7 Conclusions

We have presented a framework for a dialogue information retrieval system that is able to collaborate with the users in order to refine their queries. Collaboration is achieved through the inference of the user attitudes, and the dialogue structure. Our framework was implemented over a legal web information retrieval system and it has been used by the public since the beginning of the year 2000.

References

[CCC98] J. Chu-Carroll and S. Carberry. Response generation in planning dialogues. *Computational Linguistics*, 24(3), 1998.

[CL99] Sandra Carberry and Lynn Lambert. A process model for recognizing communicative acts and modeling negotiation subdialogs. *Computational Linguistics*, 25(1), 1999.

[LA87] Diane Litman and James Allen. A plan recognition model for subdialogues in conversation. *Cognitive Science*, 11(1), 1987.

[Loc98] Karen E. Lochbaum. A collaborative planning model of intentional structure. *Computational Linguistics*, 24(4), 1998.

[MP93] Johanna Moore and Cecile Paris. Planning text for advisory dialogues:capturing intentional and rhetorical information. *Computational Linguistics*, 19(4), 1993.

[Pol90] Martha Pollack. Plans as complex mental attitudes. In Philip Cohen, Jerry Morgan, and Martha Pollack, editors, *Intentions in Communications.* MIT Press Cambridge, 1990.

[PQ98] L. M. Pereira and P. Quaresma. Modeling agent interaction in logic programming. In *Proc of the 11th Int. Conf. on Applications of Prolog*, Tokyo, Japan, 1998.

[QL95] P. Quaresma and J. G. Lopes. Unified logic programming approach to the abduction of plans and intentions in information-seeking dialogues. *Journal of Logic Programming*, 54, 1995.