Question/Answer Dialogues for interfacing a Database with Supreme Court Decisions *

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Abstract

In this paper we present a dialogue system that is able to entertain a conversation with an user who poses questions about the existence of Supreme Court Assents with some particular characteristics. The system we propose, is able to handle ambiguities in the user questions, clarifications made by the user and the situations where the user starts parallel discourses by introducing incompatible characteristics in his questions.

Introduction

We have build[1] a Database with a set of knowledge bases where each knowledge base has the information conveyed by a Supreme Court Assents. Each knowledge base is built as a consequence of pragmatic interpretation of a text(RL93a; RL94; RL95). The result of the pragmatic interpretation of a text is a set of text temporal structures, one for each possible interpretation. So each Knowledge base is a set of text temporal structures(RL92a; RL93a; RL94; RL95; RL95; Rod94).

The dialogue system controls both the conversation with the user interrogating the system and the query of the Database with Supreme Court Assents. The user organizes his questions in order to obtain the set of Supreme Court Assents that match the set of characteristics phrased by the user in his question. An illustrative example would be:

Q1- How many Supreme Court Assents there are where an unemployed murdered his wife?

A1- 31

In order to be collaborative and to produce an answer the system should check which knowledge bases entail (the pragmatic interpretation of) the sentence: "an employed murdered his wife", and count them. This process is done through the inference of the users' intentions (to be informed about the number of Supreme Court Assents with a specific characteristic) and the abductive inference of the actions that may satisfy the users' goals. It is this planning process that includes de knowledge base query. Afterwards, the answer is planned and issued. These intentionality and activity features of our system distinguishes it from other theoretical approaches ((AKPT91; CMP90; Pol90; Car88; TH92)).

In this paper, we assume the user presents some characteristics of the set of texts he wants to see. Depending on the number of texts, he may want to restrict his search space by specifying additional characteristics. In the previous example the user could ask:

Q2: And where he killed her with poison.

A2: 2

When the user poses question Q2, he intends to continue the characteristics presented in Q1. This means that Q2 should be interpreted as:

How many Supreme Court Assents there are where:

An unemployed murdered his wife. He killed her with poison.

In order to control this kind of dialogues our dialogue system represents and reasons about the intentions of the user as well as its own intentions. This, together with an adequate representation of time intervals, enables the system to identify an interpretation context for each question. These features allow the system to handle with elegance and with the right cognitive attitudes the following dialogue phenomena:

- Ambiguity in the interpretation of the characteristics explicitly phrased by the user in each question.

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[1] By now we only have processed 20 Portuguese Supreme Court Assents with human supervision of the results during text processing

As we shall present later, this may happen very often and the system must me able to commit itself with one interpretation in order to supply an answer. This means that it must make explicit in its answer the main differences of the possible interpretations of the user question. Note that in the criteria for choosing one interpretation the system may take into account the easiest difference to phrase, not all differences can be phrased.

- Parallel sub-dialogues, this phenomena happens when the user phrases some characteristics that are incompatible with others that were phrased in a previous question.
- Clarification, an intervention of the user that:
  - informs the system that the interpretation it has chosen is not the one the user intended.
  - and phrases the differences between the system interpretation and the intended interpretation.

The interpretation context of a user question is represented with a set of temporal text structures. For this particular domain (characteristics of supreme court assents supplied by an user in his questions) the text temporal structure is well suitable because:

- it allows us to solve some discourse phenomena(RL92a; RL93a; RL93c; RL93b; Rod94) such as:
  - temporal anaphora
  - pronominal and nominal anaphora
  - detecting inconsistent discourse (namely when there are incompatible characteristics conveyed by the user questions)
- it allows us to represent ambiguity, by assigning a different temporal structure to each interpretation.
- it allows us to obtain the differences between interpretations and enables the system to be able to phrase them in its answers when it needs to make a clear commitment.
- it allows us to check if an interpretation entails the clarification made by the user. When the user makes a clarification, in the clarification there is a phrase that is not entailed by the interpretation the system assumed to be the one intended by the user. So the system must check if any of the alternative interpretations entails the user phrase. If none of the alternatives entails it then the system must choose one interpretation that is consistent with the phrase in the user question and it must interpret the phrase in that context in order to obtain the user intended interpretation.

Overview of the system

We are building a system that is able to answer questions about supreme court assents that describe situations specified by a user. The system interacts with the user through a natural language dialogue that is controlled by our dialogue system.

The Database with the Supreme Court Assents

The Supreme Court Assents are processed one by one in order to obtain a knowledge base for each of the texts.

The knowledge base represents one text as a set of text temporal structures. Each one represents one possible interpretation of the text. As it will be presented in the next section, given a text temporal structure it is possible to check if another text temporal structure is entailed or consistent with the first one.

Let Stts be a set where each element is a text temporal structure that represents one of the possible interpretations of the situation described by the user.

Let kbtext_i be the knowledge base that has all the text temporal structures for the Supreme Court Assent number i.

Let DbTexts be the Database that has all the knowledge bases with the texts.

- Given a text temporal structure tts_j in Stts, the set of numbers of Supreme Court Assent that describe that interpretation of situation j is:

  $\{k|\ \text{kbtext}_k \text{ in DbTexts and } \text{kbtext}_k \text{ entails } \text{tts}_j\}$
- A situation described by the user is ambiguous if there exists tts_i, tts_k in Stts such that $\{k|\ \text{kbtext}_k$ in DbTexts and kbtext_k entails $\text{tts}_i\} <> \{l|\ \text{kbtext}_l$ in DbTexts and kbtext_l entails $\text{tts}_j\}$.
- A given kbtext_i entails tts_j if there exists a tts_x in kbtext_i such that tts_x entails tts_i.
- So, to check if a Supreme Court Assent describes a situation specified by a user:
  1. The set of text temporal structures that represent the specified the situation is built (see next section)
  2. And check if any of the text temporal structures that are in the knowledge base of the supreme court text entails all the temporal structure in 1. To conclude that the text describes the situation it is enough to find one structure that entails all the structures in 1.

The Interface with the users

The user interacts with the system through a dialogue. The system must be able to obtain the dialogue conversation context in order to be able to recognize the user intentions.

First, the dialogue system recognizes the speech acts conveyed by the user question. In this paper we consider the following speech acts ((CL95; Per90; LA87)):

- request
- inform

As it will be shown, each speech act has consequences, namely about the systems beliefs about user intentions and beliefs.

By now we consider as possible user acts:

- request to be informed on the number of Supreme Court Assents that describe a situation (How many ....)
- request to be informed on the numbers (names) of Supreme Court Assents that describe a situation (Which ....)
- inform (clarify) the system about a previous intention that was not correctly recognized by the system (No ....)
- inform the interpretation context of the question (the interpretation context is not marked by a clue word).

Note that the recognition of the user speech acts and and the inference of his intentions requires the recognition of the user intended context for the interpretation of his question. This problem will be analyzed in the next sections.

Example of a user session

The following dialogue is a simulation of a possible dialogue in our system

Q1-How many Supreme Court Assents there are where a man murdered the woman that he lived with.

A1-143

Q2-And where at the time of the murder he was drunk.

A2-89

Q3-They were married.

A3-34

Q4-They were divorced.

A4-24

Q5-He killed her with a knife

A5-9. They were divorced.

Q6-No. Where they were married.

A6-17

In this example Q2 is a continuation of Q1 and Q3 is a continuation of Q1-Q2. The main problem is that Q4 is not compatible with Q1-Q2-Q3 and it should be a continuation of Q1-Q2. Then Q5 may be a continuation of three possible structures: Q1-Q2-Q4, Q1-Q2-Q3, and Q1-Q2. In the example it was chosen the first option. With Q6, the user makes a clarification sentence ans explictly says that the structure should be Q1-Q2-Q3.

In the next section it will be shown how our system handles the problems rised by this example: parallel sub-dialogues and clarification.

The Text Temporal Structure

One of our goal is to process texts in order to extract the information conveyed by the sentences of these texts. In order to obtain the meaning of a text sentence, we must relate the entities of each sentence with those introduced by previous sentences aiming to solve discourse phenomena such as: definite nominal anaphora, pronominal anaphora, verbal and nominal ellipsis, sentence tense and aspect interpretation, etc. The process that enables a computer to relate the entities of each text sentence with those introduced by previous text sentences is referred to in the literature as pragmatic interpretation of discourse entities (PP91; GS86; HSAM90). This is carried out by taking into account world knowledge, the situation described by the text already processed and the salience of the entities introduced by the sentences in the discourse (Web88; GS86).

The pragmatic interpretation of sentence tense and aspect requires a discourse structure (Web88; HSAM90; RL92a; RL93a; LAO92), a knowledge base with general knowledge about events, states and time intervals, and the representation of the events and states already described by the text (KR83; Par84; Ebe92; LAO92; LO93; RL92a; RL93a; KR93). One of the results of the pragmatic interpretation of tense and aspect of a sentence is the temporal anchoring of that sentence's main eventuality. A temporal anchoring of an eventuality is a temporal relation between

the eventuality's time interval and the time interval(s) of eventuality(ies) of previous text sentences (Web88; MS88; Pas88; Ebe92).

The pragmatic interpretation of a text sentence in the context provided by the interpretation of the previous sentences, namely for temporal anaphora resolution, requires a set of previously introduced referents which can be used as anaphoric referents (KR83; Par84; LO91; LAO92; RL92a; RL93a; KR93). In order to obtain the set of possible referents for the pragmatic interpretation of each text sentence's tense and aspect, we must build a discourse structure: the text temporal structure that we have presented in our earlier work (RL92a; RL92b; RL93a; RL93c).

This structure provides the visible entities (the most salient ones) for the pragmatic interpretation process.

This structure is made up of discourse segments that reflect how the eventualities introduced by new sentences relate temporally to salient (visible) eventualities of the temporal discourse structure. Each text segment has features for kind, time, eventuality and subsegments. According to the kind of a segment, its subsegments must obey some temporal constraints, and the features time and eventuality are computed bottom-up from the features of its subsegments. Every sentence is represented by a segment, its pragmatic interpretation will involve inserting it into the text temporal structure. Since the segmentation is based on the temporal properties of the segments, there are some temporal relations that must be inferred in order to be able to insert a new segment into the text temporal structure.

Regarding the pragmatic interpretation process, we follow the proposal of Hobbs et (hobs90) and view pragmatic interpretation as abduction. This means that the interpretation of a text is the minimal explanation of why the text would be true. So, the sentence tense and aspect interpretation is the explanation of why the main sentence eventuality would be true in the context of the previously acquired temporal facts. As a sentence eventuality is always a state or an event, the explanation of the eventuality is always a set of assumptions that will allow the prediction or explanation of the eventuality from its interpretation context.

In (Rod94; RL93c) a sentence interpretation process is driven by the attempt to justify the sentence's main eventuality. So the tense interpretation theory, given an intermediate sentence semantic representation, gives rise to a set of abduced predicates that explain the sentence from knowledge acquired with the previously interpreted text sentences. However, the sentence tense is interpreted in the sentence context, i.e. only the information contained in visible segments of the text temporal structure is taken into account. Some of the solutions for the tense interpretation can be contradictory with the information conveyed by previous text sentences that are no longer in visible segments. To eliminate these solutions we have to check the consistency of the knowledge base with the information conveyed by the previous sentences updated with the new sentence representation.

To perform this consistency checking operation on the knowledge base we shall implement the knowledge base in a logic programming framework, a contradiction removal system (ADP95). This implementation also allows us to check if an expression is a logic consequence of the knowledge base. This operation is important during the pragmatic interpretation of sentences' tense, namely for testing the preconditions for the abduction of a contingency relation (cause, consequence, etc) between two eventualities.

Comments on the example

Q1- Gives rise to the following temporal structure:

s_1	basic	perfect
t_1	e_1	occurs(e_1, t_1)
$x_1, x_2, e_1, t_1, e_2, t_2$: occurs$(e_1, t_1)$, evt($e_1$,murder$(x_1, x_2)$), occurs$(e_2, t_2)$,evt($e_2$, liveswith$(x_1, x_2)$), man$(x_1)$, woman$(x_2)$, $t_1 \subset t_2$.		

Figure 1: Segment s_1

Q2- Can not be interpreted alone, because of the use of the pronominals. The interpretation for this question has the following structure:

s_{12}	cont	perfect
t_1	e_1	occurs(e_1, t_1)

s_1	s_2	basic	progressive
	t_3	e_3	holds(e_3, t_3)
	x_3, e_3, t_3, e_4, t_4 holds(e_3, t_3), evt(e_3,drunk(x_3)), occurs(e_4, t_4), evt(e_4, murder(u_1, u_2)), $e_1 = e_4, x_1 = x_3$, $t_1 \subset t_3$.		

Figure 2: Segment s_{12}

Q3- Again, only can be interpreted in the context provided by the previous questions

Q4- Can not be interpreted in the context of structure s_{13} because it gives rise to a structure that is

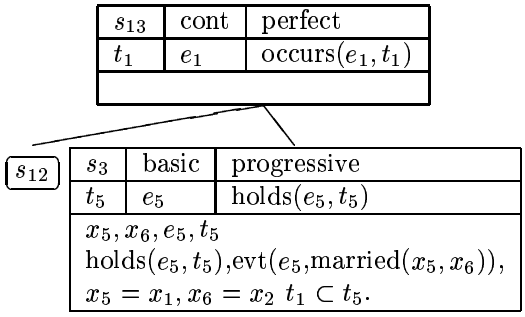

Figure 3: Segment s_{13}

not consistent, married and divorced can not be true at the same time (the time of the murder). So the dialogue system will define the structure s12 as the interpretation context for part of question Q4. Note that the new structure, s_{14} is similar to s_{13} except that the term evt will have divorce instead of married.

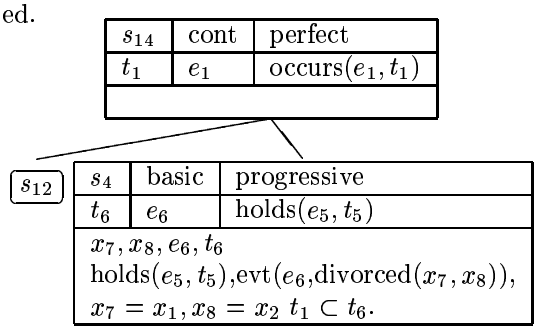

Figure 4: Segment s_{14}

Q5- will be inserted, by command of the dialogue system in the structures s_{12}, s_{13}, s_{14} (see next section). When the dialogue system asks for the differences between those structures the answer will be: the structure s_3, because it is not present in structures obtained from joining s_5 to s_{12} and s_{14}, the structure s_4 because it is not present in structures obtain from joining s_5 to s_{12} and s_{13}. So the system may commit itself to structure s_{135} or s_{145} because the differences are easy to be phrased. In the example the system chooses s_{145}.

Q6 - This is a clarification, so the dialogue system wants a structure that is compatible with the characteristics phrased by the user ("He killed her with a knife"). Structure s_{145} is the only one that entails Q6.

The Dialogue system

The dialogue system tries to recognize the users intentions and it acts in order to satisfy them. For instance,

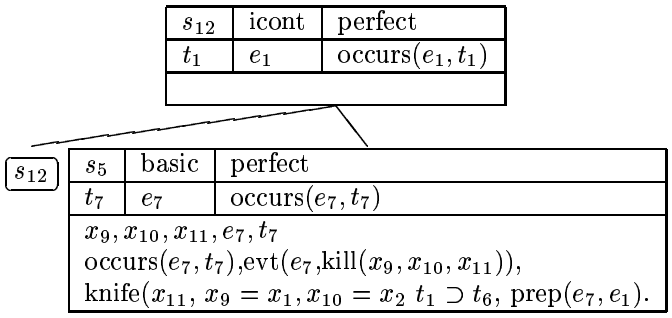

Figure 5: Segment s_{125}

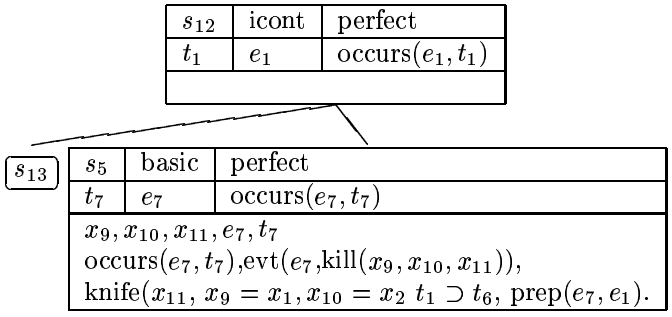

Figure 6: Segment s_{135}

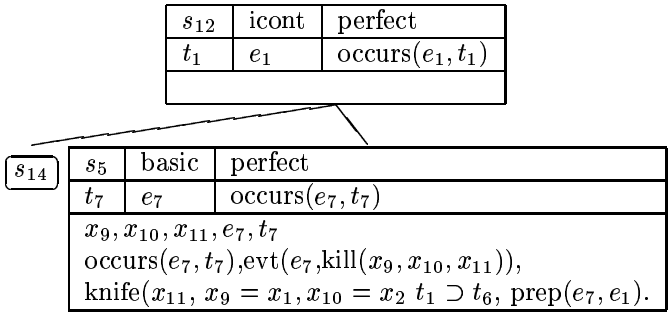

Figure 7: Segment s_{145}

in the user's first question of the example, the dialogue system recognizes a request speech act from the user asking to be informed about the number of Supreme Court Assents with a specific characteristic. This request speech act transmits a user intention and the system should act in order to satisfy it: it should obtain and inform the user about the knowledge bases that entail the situation described.

In order to represent and to reason about its users' intentions the system needs to represent two different attitudes: beliefs and intentions. In fact the representation of its own beliefs (including the system beliefs about users' beliefs and intentions) and its own intentions is the basis of the planning and the acting process. This process has as input system's intentions and it executes the intended actions whenever it is possible, i.e. there are no unsatisfied pre-requisites.

In our system we are assuming that all agents (users and system) are well behaved, i.e., they are cooperative, credulous, and sincere. Using this assumption, we can describe the effects of the analyzed speech acts in the following way (see (QL95; Qua97) for a description for other kinds of agents):

request(S,H,A) causes bel(H, int(S, A)); after a request for a specific action, the hearer starts to believe that the speaker intends the action will be executed.

inform(S,H,P) causes bel(H, bel(S,P)); after a inform action, the hearer starts to believe that the hearer believes in the informed proposition.

The dialogue system is built over a logic programming framework that allows non-monotonic reasoning: (well-founded semantics of extended logic programs with explicit negation, WFSX, from the work of Pereira et al. (AP96)) and it is represented by an extended logic program that can be decomposed into several modules:

- Description of the effects and the pre-conditions of the speech acts (inform and request) in terms of beliefs and intentions;
- Definition of behaviour rules that define how the attitudes are related and how they are transferred from users to the system (cooperatively);
- Temporal formalism (based on Event Calculus).

When the user poses a question the agents' model (logic program) is updated with the description of the event that occurred. This description captures the speech acts associated with the question and the set of text temporal structures that represent the possible interpretations of the situation described by the user. Using this information it is possible to calculate users' intentions (using the speech acts definitions) and to interact with the database in order to obtain the information needed to answer the user (using the set of text temporal structures). A complete description of these processes is presented in (QL95; Qua97).

In this section, we will show how the dialogue process is done using the example presented previously:

- After the first question the system recognizes a request speech act:
  - request(u,s,inform(s,u,(how_many(X):s_1))); where u stands for user, s for system, and s_1 is the set of text temporal structures for question Q1. As this question was the first one there is no previous dialogue context and s_1 is obtained only from Q1 (see the previous section).
- The recognized speech act has the following effect:
  - bel(s,int(u,inform(s,u,how_many(X):s_1))); meaning that the system believes that the user wants to be informed of how many Supreme Courts there are where s_1;
- As the system is a cooperative one, it tries to satisfy the user and it asks the database the desired information: query(how_many(X):s_1) – X is the number of knowledge bases that entail s_1;
- The system informs the user about the desired information:
  - inform(s,u,how_many(143):s_1).
- Question Q2 is similar to Q1 except for the fact that it is necessary to join the question with a previous dialogue context (set of text temporal structures). This joining process is done by obtaining the previous set of text temporal structures that is compatible with the question. In Q2, this set is s_1 and Q2 is joined with $s_1$obtaining s_{12}, i.e., Q2 is interpreted in the context of s_1. The system has the following belief:
  - bel(s,int(u,inform(s,u,how_many(X):s_{12})));

  The answer process is similar with Q1.
- The user's Q3 question is similar with Q2 and the joining process joins s_{12} with Q3 obtaining s_{123}. The system's belief and the intentions of the user is:
  - bel(s,int(u,inform(s,u,how_many(X):s_{13})));

- After Q4 there is a new problem: Q4 can not be joined with s_{13} because it is incompatible. In this case, Q4 should be joined with s_{12} obtaining s_{14}. The answer process is similiar with the previous ones.The system's belief is:
  - bel(s,int(u,inform(s,u,how_many(X):s_{14})));
- With Q5 the user poses a question that can be joined with three sets of temporal structures: s_{14} (the previous one), s_{13} (the other branch of the incompatible dialogue), or s_{12} (the root of the incompatible dialogue). The system must choose between the sets and this process may take into account pragmatic and cognitive knowledge. In the exemple we have chosen the previous set (s_{14}). Note that the system must identify the chosen set and make it explicit in the answer.The system's belief is:
  - bel(s,int(u,inform(s,u,how_many(X):s_{145})));
- Q6 is a clarification question. In this situation the system recognizes two speech acts:
  - inform(u,s,no).
  - request(u,s,inform(s,u,how_many(X):s_{135}))
- In a clarification question the set of temporal structures is obtained from one of the other previous compatible structures. In this example the user informs that the intended set is s_{135}. The answer process is similar to the previous ones.

As it was shown the dialogue system has the capability to represent the questions speech acts and the dialogue contexts. Using these information it is possible to infer the users' attitudes and, as a consequence, the system's attitudes. The inferred attitudes are the basis of the interaction with the database and the answer process.

Conclusions

The main features of our dialogue system are:

- That it is able to revise user intentions when they are inconsistent with the system believes or when the system believes that the user has not conscience of the consequences of is intentions. For instance when the user asks for the names of the texts and there are 1834 of them the system will first tell him the number and only if the user insists it will tell their names.
- That it only deals with the ambiguity of the user questions when it is strictly necessary to do it. If the description of a situation may be understood as ambiguous, there is more then one text temporal structure to represent it, the dialogue system considers the description ambiguous only if the set of Supreme Court Assents that satisfy the structures is different
- That in case of ambiguity it has the possibility of defining a criteria to choose one interpretation based on different cognitive aspects such as:
  - The best answer to the question
  - The facility of expressing (phrase) the choice made by the system
- That it is able to deal with user questions that are contradictory with the previous dialogue context. In this case, the system is able to obtain the previous non-contradictory dialogue context. Moreover, in the next questions the system mantains a set of possible dialogue contexts continuations and chooses the best one (using some preference rule).

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