A Proposal of Algorithm for Solving Definite Descriptions through Dialogue Structure

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Resumen In this paper we present a proposal of algorithm for definite description resolution through the structure of dialogue defining an anaphoric accessibility space in Spanish. This algorithm is based on the theoretical hypothesis that anaphora resolution and the dialogue structure are related. The definite description resolution improve if we can specify the accessibility space of each definite description with the dialogue structure. This anaphoric accessibility space is built with a series of open sequences where the coreference is likely used. The use of this anaphoric accessibility space reduce both the computational time and the possibility of obtaining an incorrect antecedent in the resolution process. Moreover, the definition of this anaphoric accessibility space based on dialogue structure only depends on the self structure.

1 Introduction

Dialogue systems constitute a very exploited group of applications in natural language processing. Nevertheless, until a few years ago, this kind of systems were developed as isolated domain dependant systems. Nowadays, there is a increasing interest in obtaining NLP resources providing the basis for generic dialogue systems that can be applied to whatever domain with only performing minor changes in some of their modules.

According to this, in [1] a generic architecture for dialogue systems is described. This architecture is based on the use of several modules, mostly of them domain independent, and some of them domain dependent but easily adaptable to whatever domain. According to [1] , one of the most critical domain independent modules in dialogue systems is the Dialogue Manager (also called the Interpretation Manager). This module is responsible for the interpretation task: it coordinates a range of processes to recognize the user's intentions underlying the utterance and to compute new discourse obligations.

In this way, one of the domain independent modules that is invoked by the Discourse Manager is the Reference Manager. The Reference Manager must be domain independent in order to be easily adapted to whatever dialogue system and it will attempt to identify likely referents for referring expressions (coreference resolution). The Reference Manager must use the accumulated discourse context from previous utterances plus knowledge of the particular situation to identify candidates.

Previous work about coreference resolution showed several linguistic and statistical rules that had been adopted in order to define the suitable candidate in each situation.

These rules involved morphologic, syntactic and semantic information. However, our state is that also information about dialogue structure must been used in order to solve the coreference in dialogues.

In this paper we will present a proposal of nominal anaphora resolution algorithm that solves the coreference due to definite noun phrases (definite descriptions) in dialogue systems. We will focus on direct anaphora resolution (where the anaphoric expression has the same head than its antecedent or the head is omitted) and on “bridging” anaphora: “definite descriptions that have an antecedent denoting the same discourse entity, but using a different head noun” [10] and between these head nouns exist a lexical relation (synonymy, hyponymy, hypernymy, and so on).

We will show an algorithm for definite description resolution based on the structure of dialogue. This algorithm looks for possible antecedent in different accesibility spaces from different kind of definite descriptions.

The organization of the paper is as follows: section 2 presents a possible representation of the dialogue structure performed by the authors, section 3 shows the anaphoric accessibility space on is based our algorithm, and finally, section 4 shows the main steps of the algorithm that we propose.

2 An annotation scheme for dialogue structure

For successful anaphora resolution in dialogues, we assume that it is essential to identify dialogue structure [7]. Therefore, we propose an annotation scheme for Spanish dialogues that is based on work carried out by Gallardo [3], who applies the theories put forward by Sacks *et al.* [9] concerning (conversational) turn-taking.

We use an annotation scheme based on these theories for three main reasons. First, as it is a general approach to dialogue modeling, it is applicable to all types of dialogues, including both task-oriented and information-retrieval-oriented dialogues. Consequently, the use of such a model as a basis for developing our anaphor resolution procedure allows us to apply the procedure to any type of domain, thus offering an advantage over procedures based on discourse models specific to particular domains. Second, this annotation scheme can be easily applied to automatic processes without metalinguistic considerations. Although in our work the annotation task has been performed by hand, for dialogue-based applications in which our procedure might be embedded (e.g., in dialogue management systems), annotation tasks must be performed automatically. Finally, we wanted to base our own procedure on studies of the influence of dialogue structure on anaphora resolution that were carried out by Fox [2], whose approach, in turn, is based on that of Sacks *et al*.

According to these theories, the basic unit of conversation is the *move*, which informs the listener about an action, request, question, etc. Moves are carried out by means of *utterances*.[1] And utterances are joined together to become *turns*.

Since our work was done using spoken dialogues that had been transcribed, turns are annotated in the texts and utterances are delimited by the use of punctuation marks

[1] An *utterance* in a dialogue is equivalent to a sentence in a non-dialogue, although, because of the lack of punctuation marks, utterances are recognized by means of speakers’ pauses.

or by the ends of turns. Reading a punctuation mark (., ?, !, ...) allows us to recognize the end of an utterance. These tasks do not affect the anaphora-resolution process.

As a result, we propose the following annotation scheme for dialogue structure:

Turn (T) is identified by a change of speaker in the dialogue; each change of speaker presupposes a new turn. On this point, we make a distinction between two different kinds of turns:

- An **intervention turn (IT)** is one that adds information to the dialogue. Such turns constitute what is called *the primary system of conversation*. Speakers use their interventions to provide information that facilitates the progress of the topic of conversation. Interventions may be **initiatives (IT$_I$)** when they formulate invitations, requirements, offers, reports, etc., or **reactions (IT$_R$)** when they answer or evaluate the previous speaker´s intervention. Finally, they can also be **mixed interventions (IT$_{R/I}$)**, which is a reaction that begins as a response to the previous speaker's intervention, and ends as an introduction of new information.
- A **continuing turn (CT)** represents an empty turn, which is quite typical of a listener whose aim is the formal reinforcement and ratification of the cast of conversational roles. Such interventions lack information.

Adjacency pair (AP) (also called **exchange**) is a sequence of turns headed by an initiation intervention turn (IT$_I$) and ended by a reaction intervention turn (IT$_R$). This form of anaphora, in which the reference appears within an adjacency pair, appears to be very common in dialogues [2].

Topic (TOPIC). The topic must be a lexical item that is referred to frequently. According to Rocha [8], four features are taken into account in the selection of the best candidate for a discourse topic: frequency, even distribution, position of first token, and semantic adequacy. A highly frequent element that occurs intensively in a passage of the dialogue but does not appear for long stretches is not likely to be a good choice for discourse topic. In the same way, neither is an element whose first appearance occurs a long way from the beginning the best choice. Moreover, semantic adequacy must be considered for the candidate, and it must be assessed by the annotator.

Based on the above-mentioned structure, then, the following tags are considered necessary for dialogue structure annotation: **IT**$_I$, **IT**$_R$, **CT**, **AP**, and **TOPIC**. The AP and TOPIC tags will be used to define the anaphoric accessibility space, and the remaining tags will be used to obtain the adjacency pairs. The IT$_{R/I}$ tag, representing mixed interventions, is not included since mixed interventions can be annotated as IT$_R$ plus IT$_I$. This task is done in the annotation phase.

3 Anaphoric Accessibility Space in Dialogues Structure

Based upon the above-mentioned annotation, in Palomar and Martínez-Barco [7], an anaphoric accessibility space was proposed for Spanish in order to resolve anaphors in the form of personal and demonstrative pronouns.

That proposal was based on previous work by Fox [2], who asserted that the first mention of a referent in a sequence of contexts is performed with a full noun phrase. After that, by using an anaphor the speaker displays an understanding that sequence has not been closed down.

To build an anaphoric accessibility space, Palomar and Martínez-Barco performed an study of the different sequences that could be open when an anaphor appears. These sequences were the following:

– the adjacency pair containing the anaphor, plus
– the adjacency pair preceding the adjacency pair containing the anaphor, plus
– any adjacency pair including the adjacency pair containing the anaphor, plus
– the noun phrase representing the main topic of the dialogue.

The anaphoric accessibility space proposed in Palomar and Martínez-Barco [7] showed successful results when it was applied together with a pronominal anaphora resolution algorithm. According to their proposal, the algorithm looked for the solution in that space, discarding solutions out of those sequences. Furthermore, an adequate ordering of those sequences was used to improve the preference system used giving different importance to solutions appearing in each kind of sequence. Authors showed an improvement of 20% when the anaphoric accessibility space was incorporated.

Based on this work [7] and on our previous empirical study [6], we have established the same four structural anaphoric accessibility space components for definite descriptions resolution:

1. Same adjacency pair (SP): the definite description and its antecedent are located in the same adjacency pair.
2. Previous adjacency pair (AP): the antecedent is located in the previous adjacency pair.
3. Nested adjacency pair (NAP): the antecedent is located in a high level adjacency pair, that includes the adjacency pair of the definite description.
4. Topic of discourse (T): the antecedent is, directly, the topic of discourse[2].

4 Description of the Algorithm

4.1 Kinds of Definite Descriptions

Based on our previous empirical work [6], we have focused our interest in the next kind of definite descriptions[3]:

1. Definite descriptions that have a relation of repetition with their antecedent: This is the most common and the most important kind of definite description.
   For example:

[2] The antecedent of a definite description can be located beyond the previous adjacency pair too. However, we have not focused our interest in this kind of accessibility space; except when the antecedent is the main topic of discourse

[3] About the different classifications of definite descriptions, see [10], [4],[5].

OP: tiene a las seis en punto un Euromed, luego a las siete de la tarde un Estrella (...), a las siete y media **un Talgo** (...)
*you have an Euromed at six o'clock, then an Estrella at seven o'clock (...), **a Talgo** at half past seven (...)*
US: sí (...)
yes (...)
OP: **el Talgo** de las diecinueve treinta (....)
***the Talgo** at nineteen thirty (...)*

2. Definite descriptions that have a elliptic head noun. In this kind of definite description, the noun of the nominal phrase is elliptic. The phrase consist only in a determiner and an adjectival or prepositional phrase.
For example:
OP: ¿qué quiere ir, **en cabina de cuatro**, de dos o de uno?
*what do you want to go, in a **four**, two or one people **cabin**?*
US: depende del precio, a ver
it depends on the price, let me see
OP: **la de cuatro** vale nueve mil pesetas (...)"
***the four one** costs nine thousand pesetas (...)*
3. Definite descriptions that have a lexical relation (synonymy, hyponymy, hypernymy, and so on) with its antecedent.
For example:
US: serían dos adultos y **un niño** (...)
*it would be two adults and **a child** (...)*
OP: si quieren ir los dos solos con **el bebé** en una cabina (...)
*if you want to go alone both with **the baby** in a cabin (...)*

4.2 The algorithm

The proposed algorithm follows the next steps:

1. Looking for possible antecedents in the same adjacency pair.
   (a) Looking for the same definite description (repetition).
      i. If such antecedent is found, this is the solution.
      ii. Else go to step 2.
   (b) Looking for antecedents with the same noun head of the definite description.
      i. If such antecedent is found, compare pre- and post-modifiers:
         A. If modifiers of the definite description and modifiers of the candidate are semantically compatible, then a high weight to this possible antecedent is assigned and go to the next accessibility space (step 2).
         B. Else, the antecedent is rejected (because they refer to different entities)[4].
   (c) Looking for antecedents with an elliptic noun head with semantically compatible modifiers.

[4] For example, "the left hand" is a different entity from "he right hand", but both NP have the same head noun.

i. If such antecedent is found, check if it belongs to a correferential chain.
   A. If it belongs, then a low weight to this possible antecedent is assigned, and continue in the next accessibility space.
   B. Else, it is rejected.

(d) Looking for antecedents with a lexical relation between the noun heads.
   i. If such antecedent is found, compare its pre- and post-modifiers.
      A. If modifiers of the definite description and modifiers of the antecedent are semantically compatible, then assign a low weight to this antecedent and go to next accessibility space (step 2).
      B. Else, the antecedent is rejected (because they refer to different entities).

2. Looking for possible antecedents in the previous adjacency pair.
   – Repeat steps *(a)* to *(d)* in the previous adjacency pair.
3. Looking for possible antecedents in the nested adjacency pair.
   – Repeat steps *(a)* to *(d)* in the nested adjacency pairs.
4. Looking for possible antecedents in the topic of discourse.
   – Repeat steps *(a)* to *(d)* in the topic of discourse.

According to the results of our previous empirical work [6], the weights that the algorithm assigns in each situation are show in the follow table:

Space	Repetition	Same Head	Elliptic Head	Bridging
SP	∞	60	25	40
AP	∞	50	20	50
NAP	∞	55	20	45
T	∞	15	40	15

Tabla 1. Weight's assignments

When the definite description is a repetition of its antecedent, this is the solution, so the weight is infinite.

When the definite description and the antecedent are related through the repetition of the head noun, it is more possible the antecedent be in the same adjacency pair than being in the topic. On other hand, this is the most common kind of relationship between a definite description and its antecedent, so the algorithm provides a high weight in general.

When the antecedent is an elliptical noun phrase, the situation is different. It is more common the antecedent be located in the topic. In our corpus, normally this kind of definite description is used to organize the macro-structure of the dialogue. For example, if the topic is "Trains from Barcelona to Pamplona", the speakers refers to they in Spanish with definite descriptions like: "el de la madrugada", "el de las tres", "el de la una", etc. With these definite descriptions, the speaker refers to the topic and opens the different sub-topics of the dialogue. This is the reason why the algorithm assigns more weight to the topic space, and less to the same adjacency space. Normally, when a elliptical definite description is introduced in a adjacency pair, the speakers refer to it with a repetition of the noun phrase.

Finally, in our corpus there are few definite descriptions with a lexical relation with their antecedent. Normally, in this kind of definite description, the antecedent is located near of the definite description, but it is not located in the same adjacency pair.

In general, together with these weights, the algorithm assigns:

- if the modifiers are the same: +10;
- if the modifiers are semantically compatible: + 5;
- if the antecedent belongs to a correference chain, the algorithm adds the weights;
- if the modifiers are semantically incompatible, the antecedent is rejected.

5 Conclusion

In this paper a proposal of algorithm for definite description resolution has been presented. The algorithm is based on the relationship between the anaphora and the dialogue structure. This relationship allows to reduce the list of candidates in the resolution process with the definition of an estructural anaphoric accessibility space. This anaphoric accessibility space is built with a series of open sequences where the coreference is likely used.

The use of this anaphoric accessibility space reduce both the computational time and the possibility of obtaining an incorrect antecedent in the resolution process. Moreover, the definition of this anaphoric accessibility space based on dialogue structure does not depend on a prefixed number of sentences [5] such as proposed by other authors (that is obviously corpus-dependent), but it only depends on its own structure.

However, there are some characteristics in the definite descriptions of the corpus that must be discussed. There are some definite descriptions that have multiple antecedents: usually, a speaker introduces some referents, and afterwards he refers to them as a whole. Both kinds of noun phrases has not been treated in this paper. Besides, definite descriptions having pragmatic relationship with their antecedent are not treated due to the lack of resources providing this information.

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[5] For example, [10]

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