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The Interplay of Desire and Necessity in Dialogue

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Abstract

The purpose of this paper is to suggest that many argumentative moves in casual dialogues can be explained in terms of conflicting desires and conflicting beliefs, in such a way that some of these moves may be predicted. Participants appraise the different outcomes of the conflicting situation and try to find, together, through dialogue, a solution that they consider as acceptable. We show how realistic dialogues can emerge through a simple recursive process from an initial cognitive conflict. This model is implemented in our program PARADISE which can reconstruct the argumentative moves of some real conversations.

Keywords: Argument generation, relevance, abduction, cognitive conflict

1 Introduction

In many applications, such as Computer Assisted Learning, text generation, contextual help systems and explanation in Knowledge Base Systems, the quality of the computer output crucially depends on its ability to generate a content that will be considered as relevant by human users. It is thus important to understand the process through which we produce the argumentative content of our utterances in everyday dialogues. While this process as a whole still remains mysterious, we claim that some of its aspects, which have a direct influence on acceptability, can be successfully simulated.

We address here the problem of the content of argumentative moves. Therefore we pay no attention, in the first place, to the linguistic form of utterances. While results produced by Conversation Analysis and Discourse Analysis (Goodwin & Heritage 1990, Moeschler 1990, Hirst 1991) may give a reference frame, they do not provide by themselves a sufficient account for argumentative moves. Surface phenomena like the embedding of utterances are not restrictive enough to reveal the process through which arguments are generated (Sadek, 1996). On the other hand, the social context of the interaction (Baker, 1991) or the conversational style of participants (Tannen, 1984) may prove to be too complex to be useful in the first place. The characterisation of speech acts is also both difficult and non sufficient for an accurate prediction of arguments (Liddicoat, 1995). Our approach addresses neither the surface level nor the social level, but rather the knowledge level. It is thus close to models based on plan recognition. There is a difference, however. These models take into account not only the knowledge shared by participants, but also second-order knowledge, as in this example from Airenti et al. (1993):

R21: $SH_{yx}\ CINT_{xy}\ p \wedge BEL_y\ sincere(x,y,p) \supset BEL_y\ BEL_x\ p$

"if it is shared by y and x that x communicatively intends that some fact p be shared by y and x, and if y believes x to be sincere with him about p, then y believes that x believes that p."

Such descriptions may be necessary in situations like goal oriented dialogues in which participants are uncertain about each other's knowledge and goals. Our claim, however, is that we can avoid the complexity introduced by epistemic statements and still account for the argumentative frame of many casual dialogues. This does not mean that no assumption is made about the participants' beliefs. On the contrary : we must have an accurate representation of what the participants know about the domain they are talking about. Simply, we make the simplifying assumption that they do not develop explicit hypotheses about what their interlocutors know or ignore. As we will see, this assumption will not appear as too restrictive in many cases.

Authors who develop computational models of argumentation first analyse the content of arguments uttered in natural contexts and study their logical effect on preceding arguments (Guez 1990, Flowers et al. 1982). The challenge is then to justify the role of each argument using a minimal knowledge, as in (Quilici, 1992). The originality of our approach comes from the strict separation between domain knowledge and dialogic principles, and from the small number of such principles.

In what follows, we introduce the notion of "cognitive conflict" by showing that many dialogues begin with an incompatibility between desires or beliefs. Then we illustrate the role of successive arguments by showing their effect on the current conflict. This leads us to the main claim of this paper: the logical structure of many dialogues results from a recursive process in which attempts to escape from a conflict alternate with the occurrence of new conflicts. This process has been implemented in our program PARADISE. Lastly, we discuss the implications and limits of this approach.

2 Cognitive Conflicts

Some dialogues are presented as resulting from the opposition between conflicting goals supported by different locutors (Flowers et al. 1982, Baker 1991). We want to extend this perspective by showing that conflicts most often do not originate between participants, but among participants' beliefs. We call them "cognitive conflicts", since they involve thoughts rather than individuals. Moreover, for our concern here which is to predict the content of argumentative moves, considering cognitive conflicts as such will prove to be more relevant than considering the social interaction itself. The following example, taken from Tannen (1984:62), will illustrate this broader notion of conflict.

Context: A, B and C were speaking about sociology, and B showed a fairly good knowledge of Erving Goffman's books. A and C are surprised, since they thought this author was known only among specialists.

```
A1- But anyway. ... How do you happen to
    know his stuff ?
B1- Cause I read it.
C1- What do you do ?
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A2- [ ? ?] are you in ... sociology or
    anything ?
B2- Yeah I read a little bit of it.
A3- Hm ?
B3- I read a little bit of it.
A4- I mean were you... uh studying
    sociology ?
B4- No.
A5- You just heard about it, huh ?
B5- Yeah. No. I heard about it from a
    friend who was a sociologist, and he
    said read this book, it's a good book
    and I read that book 'n
A6- I had never heard about him before I
    started studying linguistics.
B6- Really ?
A7- Yeah.
```

This conversation is interesting because B's strange behaviour reveals an important mechanism which is involved in the process of argument generation. Tannen explains B's reaction at the social level: B felt aggressed by sudden and intrusive questions like A1, A2 and C1, and did not answer properly until B5. What is particularly interesting for our concern is precisely the difference of acceptability between B1 and B5. B1 is not acceptable, and is repeatedly discarded by A and C (replies C1, A2, A4 and A5). We claim that B5 is relevant because it solves a cognitive conflict, while B1 is unacceptable because it leaves the conflict unchanged. The cognitive conflict arises in A and C's mind because they do not understand how B could know Goffman's books without being himself a sociologist, as revealed by Tannen who is A in this excerpt. If we consider that A and C hold the following belief:

knows (X, goffman's books) ⇒ sociologist(X)

then the belief that B is not a sociologist conflicts with his knowledge of Goffman's books. In other words, the fact that B is a sociologist appears to be both false and true: B is believed to have another profession, but at the same time his knowledge of Goffman presents him as an expert in sociology.

Now we understand why B1 is not admissible. It has no effect on the cognitive conflict. The fact that B read Goffman's books is indeed a cause of his knowing of the books, but it does not affect the conflict between this belief and the belief that he is not a sociologist. With B5, the situation changes. We have the intuitive feeling that the conflict is solved, and that B5 acted as a genuine explanation. To arrive at a more formal description, we should consider that B5 changes the knowledge hold by participants by introducing a new premise. You may know Goffman's books either by being a sociologist or by being recommended his books:

knows(X, goffman's books)
⇒ (sociologist(X) or recommends(Y,X,goffman's books))

We see that the conflict is cancelled. B may now know Goffman's books without being a sociologist. No contradiction ensues. This effect of B5 is precisely what makes this reply relevant. The architecture of this excerpt is much better understood if, before considering the social situation, we describe it at the knowledge level. This reveals a cognitive conflict which is apparent from the very beginning, and which seems to constitute the proper motivation of later replies. We will claim that many dialogues consist of successive alternations between cognitive conflicts and their solution.

3 Reconstructing Conversations

The reconstruction of arguments that were really uttered by human interlocutors during a spontaneous interaction is the best way to check the accuracy of a model that describes and predicts the content of argumentative moves. We will show in detail how the following conversation can be reconstructed at the argumentative level. In order to do so, we will first analyse how arguments are generated at the knowledge level.

Context: A is repainting doors in his home. He decided to remove the old paint first, which proves to be a hard work (translated from French)

```
A1-  I have to repaint my doors. I've
    burned off the old paint. It worked
    OK, but not everywhere. It's really
    tough work! [...] In the corners, all
    this, the mouldings, it's not
    feasible !
[...]
B1- You have to use a wire brush
A2- Yes, but that wrecks the wood
B2- It wrecks the wood...
[pause 5 seconds]
A3- It's crazy! It's more trouble than
    buying a new door.
B3- Oh, that's why you'd do better just
    sanding and repainting them.
A4- Yes, but if we are the fifteenth ones
    to think of that
B4- Oh, yeah...
A5- There are already three layers of
    paint
B5- If the old remaining paint sticks
    well, you can fill in the peeled
    spots with filler compound
A6- Yeah, but the surface won't look
    great. It'll look like an old door.
```

We observe that this conversation starts with the expression of a cognitive conflict. A wants to repaint his doors. As a consequence, he must burn off the old paint, which means working hard (because of the presence of mouldings). However, *A* would prefer avoiding such effort. The conflict results from two incompatible desires : *A* wants to remove the old paint, and he wants to avoid tough work. The relevance of *B1* appears then clearly : by using a wire brush, *A* can remove the old paint easily, and the conflict vanishes. *A* acknowledges this fact in *A2*, but also points to a new conflict : using a wire brush is desirable (to avoid tough work), but it is incompatible with the wish of having a smooth surface, since the wood gets wrecked. This conversation is a typical example of an alternation between conflicts and solutions.

The linguistic form of utterances is not relevant here. We retain only the argumentative frame, which can be sketched this way:

A1- repaint, burn-off, mouldings, tough work

B1- wire brush

A2- wood wrecked

A3- tough work

B3- sanding

A5- several layers

B5- filler compound

A6- not nice surface

The challenge is to predict each of these argumentative moves using a domain knowledge and general argumentative principles. The difficulty of the task should not be underestimated. The domain knowledge should not be designed for the purpose of the reconstruction. It should be validated in principle by an external expert. Also, the argumentative principles hold for any conversation and should not be changed to fit the actual utterances. Consider first the following domain knowledge. It is given in propositional logic and causal links (clauses C1-C8) do not mention time indexes. This is for the sake of simplicity, since what we want to illustrate is more the management of conflicting necessities than knowledge representation.

(C1) burn_off [& not wood_wrecked] → nice_surface

(C2) filler_compound [& sanding] → nice_surface

(C3) sanding [& not several_layers] → nice_surface

(C4) burn_off [& mouldings & not wire_brush] → tough_work

(C5) wire_brush [& burn_off] → not tough_work

(C6) wire_brush [& burn_off & wood_soft] → wood_wrecked

(C7) wood_wrecked → not nice_surface

(C8) repaint [& nice_surface] → nice_doors

(C9) actions([repaint, burn_off, wire_brush, sanding, filler_compound]).

(C10) atypical([wood_soft, several_layers]).

(C11) undesirable(tough_work, 10)

(C12) undesirable(not nice_doors, 20)

The premises in brackets in the causal links constitute the context in which these links apply. Some propositions are marked as actions (C9). This means that their truth value can be freely determined. Their default value is false. Other propositions are listed as atypical (C10). Their default value is also negative. Lastly, some propositions are marked as undesirable (C11 and C12). The associated value is indicative. Only their relative ranking is relevant and they may change during the argumentative process.

The problem is to show how a simple process can make use of this knowledge to generate the arguments that were really given.

4 From Knowledge to Conversation

The model, implemented in the program PARADISE, relies on two basic mechanisms: abduction and necessity management. We will illustrate how these mechanisms are involved in the reconstruction of the preceding conversation.

4.1 Example of Argument Generation

Before arriving at B1, the program must decode the situation and the motivation of actions described in A1. When A1 is given as input, the program first instantiates *repaint* as true. It recognises it as an action, using C9. By making an abduction, it infers the underlying motivation, thanks to C8: the effect does not exist before the action, therefore we have *not nice_doors* initially. This situation is undesirable with intensity 20 (C12). *nice_doors* becomes desired with intensity 20, and a cognitive conflict occurs. It vanishes immediately since *repaint* produces the desired effect, *nice_doors*, from which it acquires the necessity value 20. At this point, the program has nothing to do. The cognitive conflict has been solved and no causal link can be activated. Notice that many of the inferences performed by the program have no effect on its output. They are however necessary for the correct computation of arguments.

A1 continues with *burn-off*, which is also an action. The program similarly uses C1 to infer *not nice-surface* through abduction, and the conflict *nice_doors* / *not nice_doors* reappears since C8 is now blocked. But it vanishes immediately thanks to C1 which restores *nice_surface*. This term, like *burn_off*, inherits a necessity value 20.

A1 then reveals *mouldings* and *tough_work*. The program comes upon another cognitive conflict: *tough_work* has a necessity value 20 that is inherited from *burn_off*. But *not tough_work* is desired with the intensity 10 (C11). These conflicting desires and necessities call for a solution. This solution is obtained through abduction, thanks to C5. *wire_brush* is an action. It can be made true, and produces the wanted effect, *not tough_work*. It receives the necessity 10, the conflict is solved and B1 can be uttered.

4.2 Basic Principles used in Argument Computation

The program is given two basic abilities: abduction and the ability to propagate necessity coefficients (a deductive ability is of course assumed, but it could be part of another module). Abduction consists in inferring causes from effect. The current implementation includes only a basic form of abduction, since the it is not a proper part of our model. An abduction from *D* using the causal link:

A [& B & C] $\rightarrow$ D

is only possible if *A*, *B* and *C* are true or unknown. *A* is abducted first. The abducted term must of course be unknown. Another form of abduction consists in assuming that the effect of a new action was false before the action. For instance if *A* is an action and *D* is unknown, *not D* is assumed before *A* is performed.

The computation of necessity coefficients, which constitute the core of our model, can be described using a few principles:

(P1) if a new fact *T* is introduced that has an undesirability *N*, *not T* is produced and receives the necessity *N*.

(P2) an effect inherits the necessity of its cause.

(P3) the negation of a cause inherits the necessity of the negation of its effect

(P4) An abducted term is given the necessity of its effect

These principles control the process of argument generation. When no conflict is detected, necessity coefficients are simply propagated, according to P1-P4. A conflict arises when (T, N_1) and (*not* T, N_2) occur at the same time. N_1 and N_2 are the respective necessities of T and *not* T.

(P5) In such a conflicting situation, the program attempts to "save" the weaker term (here *not* T if $N_1 > N_2$) by looking for a cause through abduction. This is what allowed the program to find *wire_brush* and to produce B1.

(P6) When no such solution can be found, the weaker term of the conflict is negated. P3 applies and the conflict shifts to other terms.

For instance, when A2 (wood gets wrecked) is given, it reveals a conflict that the program did not anticipate. The causal link C6 had not been triggered because *wood_soft* was atypical, but now the program makes the abduction *wood_soft* through C6. A deduction through C7 leads to a conflict between (*not nice_surface*, 10), produced by P2, and (*nice_surface*, 20) which was previously memorised. No new abduction can produce *nice_surface*. As a consequence, *nice_surface*, which has a greater necessity, "wins". According to P6, *not wood_wrecked* is produced through C7 and P3, and the conflict shifts to (*wood_wrecked*, 10) and (*not wood_wrecked*, 20). For the same reason, *not wood_wrecked* is enforced, and the conflict is transferred to (*wire_brush*, 10) and (*not wire_brush*, 20). *wire_brush* looses the battle, and we are back to the situation we had before B1. No wonder that A3 echoes A1.

The remainder of the conversation is reconstructed according to the same principles. We must suppose that A's insistence on *tough_work* increases the undesirability of this term to, say, the value 30. *not burn_off* inherits the necessity 30 through C4 and P3, which is higher than *burn_off*'s necessity 20. The conflict is transferred by P6 to *nice_surface* which is set to false. There, according to P5, an abduction can be done using C3. It restores *nice_surface* and justifies B3. Similarly, after the blocking of C3 by *several_layers*, B5 is found through a further abduction using C2.

5 Technical Remarks

Our first remark concerns the knowledge representation, which is quite basic in the previous example. A realistic use of the system would of course require a more general representation involving variables, time indexes, quantification, explicit default conditions, etc. The knowledge module, however, is not a proper part of our system. It should rather be part of a semantic module. What is relevant to our model is the ability of this semantic module to detect unusual situations (*e.g.* a cause with an impossible effect) and to perform abductions. For our purpose here, which was to explain how the management of necessities allows the generation of relevant arguments, the use of a elementary knowledge representation was sufficient.

The simplicity of the dialogic principles, on the other hand, is a positive characteristic of our model. Many other approaches give the priority to an explicit representation of intentions, goals and plans pursued by interlocutors. Notions like interfering plans (Quilici, 1992), argumentative orientation or argumentative strength (Guez, 1990), preconditions, sub-plans and sub-goals, support or threat for a plan (Young, Moore & Pollack, 1994) are not made explicit in our model. Some of them emerge from the necessity management and from the abductive process. Our model is, in itself, a kind of planning program, since its output can be seen as a plan. However, it does not manipulate programs as such. For instance, when uttering B5, the program has obtained a whole plan for an apparently satisfactory repainting of the doors. Such plans result from a poorly efficient process if we compare it with classical planning programs (Kambhampati, 1997). However, as we will claim, our model is much more plausible from a cognitive perspective.

Another kind of representation which is absent in our model is second-order knowledge: knowledge about others' knowledge and about plans. In our approach, this meta-knowledge often proves to be nonessential. Whenever it is necessary, our project is to represent and to use it exactly as domain knowledge.

A further remark concerns the non-monotony of the system. This non-monotony is essential for the resolution of cognitive conflicts. Default values, which are negative for actions and atypical facts, and the fact that unknown terms do not block deductions (as *wood_wrecked* in C1 when B1 is produced) let the door open to knowledge revision when new elements are introduced. For instance, after introducing *wire_brush*, which was abducted to get out of the conflict *tough_work* / *not tough_work*, the term *tough_work* is no longer true because C4 becomes blocked.

Our last remark is about the deterministic aspect of necessity management. This is the main difference between this approach and planning programs, which use heuristics and a non deterministic goal generation. What plays the role of goals, in our model, is the weaker term of a conflict. The determination of goals is thus fully deterministic. Non deterministic aspects are limited to the abducted algorithm. Even there, the search is strongly constrained, since the effect is given as input. The use of knowledge is thus progressive and controlled, which allows to consider the use of realistic size knowledge bases.

6 Cognitive Plausibility of the Model

The first positive argument for the cognitive plausibility of our approach is its simplicity. The few principles used are quite basic from a psychological point of view. Our abductive ability, though still mysterious in its functioning, is recognised as a powerful human ability (Johnson et al. 1994, Josephson & Josephson 1994). The few principles underlying necessity management are quite natural hypotheses. Differential necessity values and inheritance through causal links can be inferred from knowledge revision phenomena (Castelfranchi & D'Aloisi, 1991). We are indeed less prone to believe that D. Scarlatti met Mozart if we know that he was born the same year as Bach. Our ability to evaluate and to solve conflicts can be seen in our capacity to balance pros and cons. Necessities are also apparent in our use of modal expression (as in "you have to use a wire brush").

The present model has been inspired by the observation and analysis of natural conversations (Dessalles, 1993). Most spontaneous conversations are organised around cognitive conflicts that are made manifest when new topics are introduced. Some conflicts can be described as apparent logical impossibilities, *i.e.* paradoxes. This is what happened in the conversation about Goffman’s books. Others cognitive conflicts are about undesirabilities, as was the case with our main example.

A third possibility, which can also be considered as a cognitive conflict, but which our model does not consider, is the mention of an improbable event. For instance:

From Tannen (1984):

```
A1- Speaking of which they had the Loud
    Family. Remember the Loud Family? On
    Saturday Night
    Live? [TV program]
B1- What was the Loud Family?
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A2- Dju hear about that? THEY TALK LIKE
    THIS.
B2- I know lots of people in New York who
    talk like that.
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Neither A1-A2, which introduce an improbable story, nor B2, which attempts to lower the improbability, can be computed in our current implementation. This would require significantly different mechanisms based on qualitative probabilities.

Another limit of the current implementation comes from the fact that meta-knowledge is not available. This may be problematic in situations in which participants are uncertain about what others know. Also, utterances like A6 in the conversation about Goffman ("I had never heard about him before I started studying linguistics") are difficult to predict. A6 was just a way of making the logical context of the conversation more explicit. By generalising A's case, we obtain the fact that non-linguists do not know Goffman, which is roughly the context that made B's knowledge of Goffman paradoxical. A's motivation for uttering A6 might be to make her surprise more manifest to B. This kind of initiative is still beyond our modelling capabilities.

7 Conclusion

We presented here a model of argument generation based on the notion of cognitive conflict. Such a conflict arises when several beliefs are incompatible, or when some fact considered as necessary is incompatible with another fact which is desired. Such conflicts are made manifest during conversation, and participants try together to solve them. Quite often a solution creates a new conflict. This is the recursive aspect of dialogue, which may cause some conversations to last for half an hour on the same topic (as in one example of our corpus which consists of 355 utterances). The basic mechanisms involved in our model were kept simple. When a cognitive conflict is recognised, participants try to make abduction from the weaker term. If this fails, they give up and assert the falsity of this term. This generally causes the conflict to shift to other terms. The new conflict is handled the same way, until a satisfactory solution is found or, as was the case in our main example, until participants are unable to make further abductions.

Further work is required to include meta-knowledge and probabilities into the model. We also plan to link the model to a proper semantic module that would allow a dynamic production of causal links. Another objective is to make the implementation robust enough to use it in real human-machine interactions, like Computer Assisted Learning dialogues.

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