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Modelling argument recognition and reconstruction

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Abstract

A growing body of recent work in informal logic investigates the process of argumentation. Among other things, this work focuses on the ways in which individuals attempt to understand written or verbalised arguments in light of the fact that these are often presented in forms that are incomplete and unmarked. One of its aims is to develop general procedures for natural language argument recognition and reconstruction. Our aim here is to draw on this growing body of knowledge in informal logic in order to take preliminary steps towards developing an architecture for computer systems that are able to recognise and reconstruct natural language arguments. This architecture aims to structure research of an applied and computational nature that strives to implement linguistic systems of various sorts, and to analyse problems in a way that both yields manageable and relatively independent components and also highlights how implementations can interact with existing resources from natural language processing.

Keywords: Arguments; Argument modelling; Argument recognition; Argumentation schemes; Artificial intelligence; Natural language processing

1. Introduction

There is a substantial and growing body of work in informal logic that investigates the processes of argumentation, including that of reasoning structure recognition and reconstruction. Such work considers the ways in which individuals attempt to understand written or verbalised arguments in light of the fact that these are often presented in forms that are incomplete (e.g. forms that do not contain an explicitly stated conclusion) and unmarked (e.g. forms that do not contain terms which, like 'therefore' or 'accordingly', are typically used to stand for inferences). Some of this work in informal logic is designed primarily to assist in the teaching of

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informal logic (see, for example, Govier, 1997). However, some of it aims primarily to develop general procedures for natural language argument recognition and reconstruction (see, for example, (Hitchcock, 1985; Gilbert, 1991)). Clearly, the identification of such procedures is of importance to research into natural language understanding in artificial intelligence (AI). Specifically, it is of importance to research into the creation of computer systems that engage in natural language argumentation or reasoning, and to research into the development of computer systems that could play a part in automating the labour-intensive process of creating text corpora of natural language arguments. Thus, taking our cue from research in informal logic, we here take preliminary steps towards developing an architecture for computer systems that are able to recognise and reconstruct natural language arguments.

Of course, a great deal of work in computational linguistics and AI has examined the tasks of natural language generation and natural language understanding in general, and some has examined argumentation as a subspecies of language (Cohen, 1987; Elhadad, 1995; Reed, 1999). However, we approach the problem from a different direction, viz., that of informal logic, and thereby exploit theoretical and empirical results that are specific to argumentation and the theory of argument (van Eemeren et al., 1996).

Our goal is to develop an architecture that can structure research of a more applied and computational nature that strives to implement linguistic systems of various sorts. This architecture is to analyse the problems in a way that yields manageable and relatively independent components, and that also highlights how implementations can interact with existing resources from natural language processing.

We begin by presenting an argument taken from the magazine *Outlook India* and following one plausible path of reconstructing it. In light of our reconstruction, we outline, in general form, a commonsense view of the steps that readers go through in recognising and reconstructing arguments. We then outline a theory of the nature of natural language arguments and show how these components can be synthesised into an architecture of a computational model that implements recognition and reconstruction of arguments. Finally, we summarise successfully implemented subsystems that substantiate the applicability of the general architecture.

2. Argument reconstruction: a case study

In the present section, we examine a short text and reconstruct it in a plausible way. Doing so will allow us to identify a number of general conclusions about how arguments are reconstructed from texts. Consider, then, the following excerpt from an article that appeared in *Outlook India* (and that is part of an online corpus of argumentation (Katzav et al., 2004)):

Excerpt 1

It's the old Orissa drought and starvation story being played out again. This time in Rajasthan. Even as the casualties mount, the state and central governments would like the world to believe that the deaths were caused by disease and lack of hygiene rather than by abject poverty and starvation. But for anyone who visits Rajasthan's Baran district, the apathy of the district administration and the failure of the Public Distribution System (pds) is clear to see. Whatever spin you give it, it is hunger that is claiming its victims [*Outlook India*, ''Grass is For Cows'', by Bhavdeep Kang, 4 November 2002].

The first thing a reader intent on reconstructing arguments needs to do in examining such an excerpt is to determine whether it does indeed contain an argument. On some occasions, terms that typically represent inferences allow this to be done. Terms such as 'thus', 'therefore' and 'accordingly' can alert the reader to the likely presence of an inference, and hence to the likely presence of an argument. If such syntactical cues are present, they are likely to be used. However, in Excerpt 1, as is often the case, there are no terms that typically represent inferences. Nevertheless, the content of the excerpt allows a reader to conclude that it does contain an argument. In reading it we come to understand that the author, Kang, is contrasting the government's claims about the causes of the deaths in Baran with his own views, and, further, we come to see that he is not merely asserting his own views but arguing for them.

We are first alerted to the fact that Kang intends to contrast two possible explanations for the casualties in Baran when he uses the phrase 'the . . . governments would like [us] to believe.' This subjunctive phrasing is characteristically used to express scepticism about what it is that it is desired that we believe, and thus leads us to expect an alternative to what it is we are supposed to believe. More importantly, after we are told what it is that the government wants us to believe, the term 'rather than' is used to state the contrast between the view that the deaths were caused by disease and lack of hygiene, and the view that they were caused by abject poverty and starvation.[1] Once we are aware that the author has noted this contrast, we expect criticism of the government's claim. This expectation is strengthened by the fact that the sentence that follows the stated contrast begins with the term 'but'. Kang writes, ''But for anyone who visits Rajasthan's Baran district, the apathy of the district administration and the failure of the Public Distribution System (pds) is clear to see''. The term 'but' suggests that what follows will be yet another statement that conflicts with the government's position. Moreover, the reader realises that it does so by describing something the presence of which would (supposedly) make it liable that hunger will claim its victims. Accordingly, the reader realises that the statement that the term 'but' introduces is supposed to be a reason to expect death as a result of poverty and starvation, and thus that it is supposed to be a reason to think that the government is wrong about the root causes of the deaths in Baran. Here, then, it becomes clear that Kang is offering an argument.

As we have seen, syntactic cues given by inferential terms need not appear in arguments, and thus cannot be relied upon in argument detection. Similarly, as formal arguments that only rely on syntactic and semantic cues illustrate, pragmatic cues such as 'they want us to believe' cannot be relied on in argument detection. Moreover, while recognising pragmatic cues yields evidence for the presence of arguments, doing so does not involve recognising arguments themselves. In the excerpt we have been considering, recognising the argument itself consists in recognising that the apathy of the district administration and the failure of the Public Distribution System (supposedly) makes liable death due to poverty and starvation, and thus that the statement that describes the apathy of the district administration and the failure of the Public Distribution System (supposedly) is a reason to expect death thus caused.[2]

After having determined that an argument is present in a text, we need to determine what exactly the argument is. Some of what is needed to do this has already been accomplished. We can conjecture that the argument's conclusion is, (a) 'it is hunger that is claiming its victims', and that one of its premises is, (b) 'the district administration is apathetic and the Public Distribution

[1] See Knott (1996, 2000) for a discussion of the rules governing the use of contrastive terms such as 'rather than'.

[2] The process of argument detection that we have been describing does make use of pragmatic considerations. However, it only gives these the role of evidence from which one *infers* that there is an argument in the text. The direct recognition of the argument is taken to consist in recognising a certain semantic fact, namely that it is supposed to be the case that certain facts make death due to poverty and starvation liable. This is what will allow us, later on, to bypass pragmatic considerations in our theory of argument recognition.

System has failed'. This conjecture can be made on the grounds that the fact described by (b) supposedly makes liable the fact described by (a).

Notice that Kang is explicit that his claims are about Baran at a particular time. Thus we assume, in a manner that is not dependent on the process of argument recognition and reconstruction, that (a) and (b) represent certain facts at this place and time, even though the information they convey does not suffice to pick out these facts. Thus, we assume that (a) and (b) are elliptical representations of what Kang in fact intends to say using (a) and (b). Specifically, we assume that (a) is elliptical for, 'it is hunger that is claiming its victims in Baran towards the end of 2002' and (b) is elliptical for, 'towards the end of 2002 in Baran, the district administration is apathetic and the Public Distribution System has failed.'

We can also, at this point, conjecture that the argument contains at least one missing premise. In determining that an argument is present, we have recognised that (supposedly) if the fact described by (b) is the case, then the fact described by (a) is liable to be the case. We have, to put things more directly, recognised that (supposedly) if the district administration is apathetic and the Public Distribution System has failed, then it is likely to be the case that hunger claims its victims. However, the argument contains no explicit claim to this effect.

What remains, then, is to determine what the argument's missing premise is. This too is achievable. Once we have grasped that the fact described by (a) is represented as conveying or bringing about the fact described by (b), we can conjecture via which relation of conveyance this is supposed to occur. Given our background knowledge, including our grasp of the nature of the facts described in (a) and (b), we can see that the relation in question involves some kind of causal dependence. Supposedly, the fact described by (a) is, in the circumstances, causally dependent upon the fact described by (b). Thus, we can assume that the connective 'then' in the missing premise 'if the fact described by (b) is the case, then so is the fact described by (a)' asserts some kind of causal dependence between what (a) describes and what (b) describes.[3]

Of course, since there are a variety of ways in which the fact described by (a) might be causally dependent on the fact described by (b), it is possible to raise other, more general or abstract conjectures about the relations between these facts, and thus additional corresponding conjectures about the premise that is implicit in Kang's argument. It might, for example, be supposed that some kind of general causal principle, or causal law, connects facts that are similar to the one described by (b) with facts that are similar to the one described by (a). Perhaps, for example, it is the case that, in a certain type of district, a combination of apathy on the part of its administration with the failure of its public distribution system is liable to cause hunger to claim its victims. If so, the missing premise would supposedly be something like 'in the appropriate circumstances, if facts of the same type as the one described by (b) are the case, then facts of the same type as the one described by (a) are liable to be the case'. There is, however, nothing in the text that would allow us to evaluate more general suggestions as to what the missing premise in Kang's argument is. Moreover, all such suggestions entail that the fact described by (a) is causally dependent on the fact described by (b). Thus, the mere conjecture of causal dependence between the particular facts described by (a) and (b) is preferable in that it is not likely to go wrong even if there is some chance that Kang is committed to more than it attributes to him. In this way, we are following a parsimonious, even minimalist, programme in the reconstruction of enthymemes.

[3] On our view, conditionals often express a kind of dependence between facts that is not captured by the material conditional of logic. Nothing significant turns on this here. Those who disagree can simply replace the term 'then' in the conditional with 'then an effect of this will be that', thus ensuring that the conditional represents a causal relation.

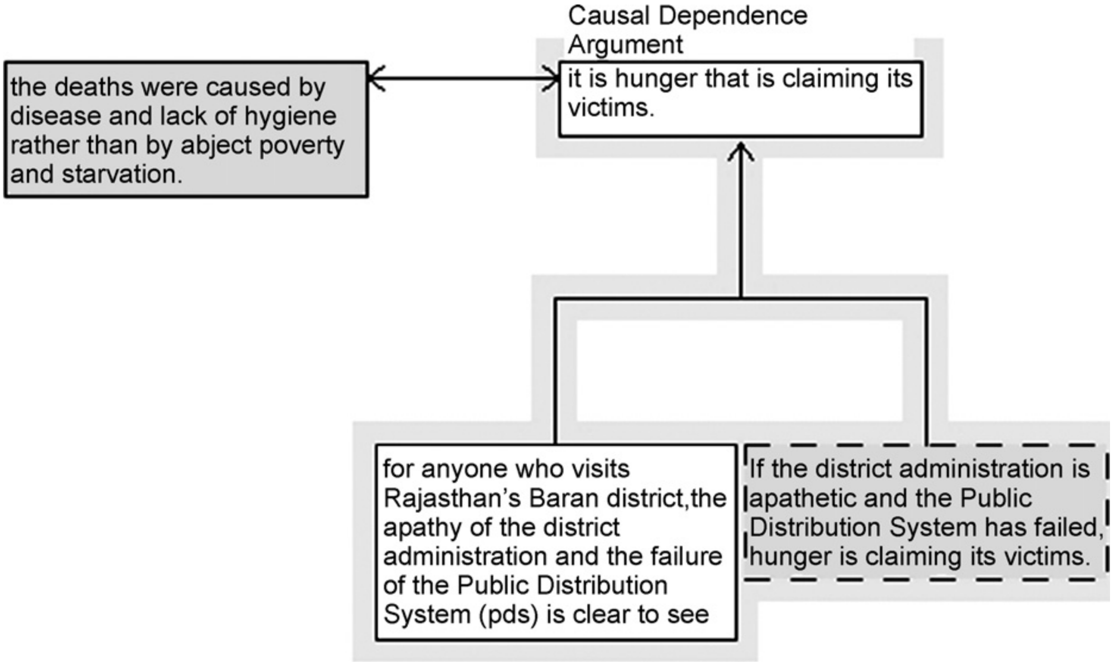

Fig. 1. A reconstruction of Kang's argument.

A plausible reconstruction of Kang's argument is, therefore, as given in Fig. 1.

The analysis diagrammed in Fig. 1 is constructed according to conventional, textbook argument theory techniques—see, e.g. (Groarke et al., 1997). These techniques have been embodied in a software tool custom built for such analysis (Reed and Rowe, 2004). In the diagram, the explicit premise and conclusion of Kang's argument are represented within white rectangles, and the reconstructed premise of his argument is represented in a grey rectangle. The premises do not support the conclusion separately. Thus, the lines drawn from the premises to the conclusion are linked to create one arrow indicating joint support. The conclusion is linked by a two-way arrow to a representation of the government's position; thus indicating that they are in conflict. In addition, Kang's premises and conclusion are all highlighted and described as a certain type of argument, namely a Causal Dependence Argument. We thus intend to convey the information that the fact described in Kang's explicit premise and the fact described in his conclusion are causally dependent and that this dependence is asserted in the reconstructed premise.

3. Argument reconstruction: presuppositions and stages

Having concluded our reconstruction of Kang's argument, we now proceed to describe, in a general manner, the stages that underlie this reconstruction and to clarify which aspects of this reconstruction we aim to model.

The process of reconstructing Kang's argument had five stages:

1. Reconstruction of explicitly represented statements
2. Argument recognition
3. Enthymeme recognition
4. Possible argument type recognition
5. Missing premise/conclusion reconstruction

Our focus here is on those stages of text recognition and reconstruction that involve argument recognition and reconstruction, that is to say those stages that are captured in 2–5. In order to model these stages, we assume that stage 1 is carried out either manually or by building on automated and semi-automated text reconstruction techniques. To be more explicit, we assume the successful conversion of input text into text with the standard form that is used by the system that is analysing it. A standardised text is one in which elliptical sentences have been replaced by complete equivalents, indexical terms have been replaced with appropriate descriptions, ambiguities have been disambiguated or noted, questions and imperatives that are in effect assertions have been replaced by assertions and all assertions are represented in some canonical or standard form that marks out their syntactic, semantic and pragmatic properties. We also assume that a standardised text explicitly marks up all those propositions that are immediately detectable by a competent reader. In reading Kang's argument, a competent reader will be immediately aware that the statement, 'for anyone who visits Rajasthan's Baran district, the apathy of the district administration and the failure of the Public Distribution System (pds) is clear to see' consists in a number of statements, including the statement that the district administration is apathetic and the statement that the public distribution system has failed. Thus, we assume that these constituent statements are explicitly marked up as components of Kang's statement about what can be seen when visiting Baran. Finally, the standardised text marks up statements in accord with the types of fact they represent.[4] Since this mark-up in accordance with fact type carries the information that we suppose enables argument recognition and reconstruction, we will discuss its role in detail as we proceed to outline our views.

The standardisation of a text does not include making implicit statements that are components of its arguments explicit. In other words, statements that are components of the text's arguments but that are not already represented in the text by some syntactical device remain unrepresented by syntax after standardisation. So too, standardisation does not include identifying arguments as being of this or that type or even as being arguments.

From a computational point of view, the tasks involved in the standardisation of texts collectively represent an enormous challenge, and we do not seek to trivialise their role. There is little agreement even upon the format that such a representation should take. Recent textbooks (such as Pereira and Grosz, 1994; Blackburn and Bos, 2005) review some of the current approaches with a heavy focus on representational aspects; broadly non-representational statistical approaches are also proving to be powerful in understanding sentence and inter-sentence meaning (Manning and Schutz, 1999), and large scale structures are then supported through techniques such as Rhetorical Structure Theory (RST) (Mann and Thompson, 1988), and Discourse Representation Theory (DRT) and its derivatives (Kamp and Reyle, 1993). Even at the most abstract levels of representation, however, it has been argued (Reed, 1999) that techniques such as RST and DRT do not adequately account for – or have the machinery to express – the structure of either surface form or deep meaning of arguments (in the sense of van Eemeren et al., 1996). Here, we want to bracket the issue of computational natural language understanding to the point of propositional sense-making, and explore the *extra* problems and opportunities presented by argumentative structure.

Of course, it has long been argued that neither natural language understanding nor its counterpart, natural language generation, should be seen as strictly pipeline processes from

[4] Facts can be viewed as coming in different species or kinds, just as, say, animals can. Thus, for example, facts can be classified as abstract or concrete, moral or descriptive, causal or non-causal and so on. So statements can be marked up (and so classified) in accordance with the species or kinds of facts they represent. If, for example, a statement represents a fact in which one object causes another, the statement can be marked up so as to indicate that it is a causal statement.

larger-scale to smaller-scale structures (de Smedt et al., 1996). There are certainly interesting interplays between large-scale argument structure and lexical choice, to take just one example (Reed, 1999). This paper, however, focuses on those larger scale features that are particularly characteristic of argument, and that might not be accounted for elsewhere. The approach is to use tailor-made theories of argument structure developed in argumentation theory, informal logic and critical thinking as the starting point for developing a computational architecture that might account for them, and might make it easier for advances in argumentation theory to be interpreted in artificial intelligence (Reed and Norman, 2003).

We begin our examination on the assumption that the process of argument recognition and reconstruction occurs from 2 through to 5 in ascending order. That this assumption can be made to work is suggested by our description of the process of recognising and reconstructing Kang's argument. In our analysis of Excerpt 1, we assumed an understanding of the statements in the text and, in light of this, identified the argument it contains. Only then did we proceed to determine what type of argument the argument is and to reconstruct the argument's implicit premise.

Nevertheless, merely proceeding through stages 2–5 in ascending order will not always do. Sometimes knowledge of the presence of an argument in a text cannot be acquired prior to missing premise reconstruction. For making an implicit premise explicit might reveal a hitherto unnoticed argument, one in which, say, the previously implicit premise is a conclusion rather than a premise. In order to address this possibility, our model will include a feedback mechanism. Having gone through stages 1–5 in an attempt to analyse the arguments within a given text, we require that a new modified text be produced by the computer system, one that is the result of explicitly appending to the original marked up text those argument components that have already been discovered to be implicit in it.[5] The modified text must itself, we will suggest, be re-submitted to the process of argument recognition and reconstruction in order to determine whether any of the modifications it contains themselves trigger yet further modifications. The analysis which our system is designed to achieve is attained only when it produces a text that can be re-submitted without alteration.[6]

4. Immediate argument detection

Assume, then, that we have a standardised version of a given text. It is on this text that the computer system is supposed to carry out the process of argument recognition and reconstruction. For a computer system to do this, it must implement an appropriate theory of what an argument is. It must also possess a relevant system of structured information and theory, as well as the ability to reason from its information and theory. In this section, we suggest one appropriate theory of what an argument is and illustrate how it can be used to enable a computer system immediately to recognise arguments within a text, that is to say to recognise arguments in a text without engaging in reasoning. We also say something about the body of information and theory that must be implemented by a computer system if it is to be able to recognise arguments. In sections 5 and 6, we discuss how the computer system is to proceed with the stages of argument reconstruction that follow immediate argument recognition. In section 7, we describe how the computer system is to proceed when argument recognition does require reasoning.

[5] More accurately, we require that the computer system produce a representation of a new text. We write as if the computer system operates directly on texts in order to avoid awkward phrasing.

[6] There are a variety of uses to which final texts produced by the computer system could be put. For example, they could be used to construct argument diagrams of the kind that we have offered in this article.

Reconstructing Kang's argument suggested that the ability to recognise the presence of an argument in his text consists in being able to recognise that the apathy of the district administration and the failure of the Public Distribution System (supposedly) makes liable death due to poverty and starvation, and thus that the statement that describes the apathy of the district administration and the failure of the Public Distribution System (supposedly) is a reason to expect death thus caused. Generalising, being able to recognise an argument consists in being able to recognise that one fact (supposedly) makes liable or necessitates another fact. Thus, it is natural to view an argument as, roughly, a proposition that represents one fact as making another fact liable.[7]

Let us explain and make more precise the view of arguments being proposed here. Propositions are the contents of intentional attitudes. They are, for example, the contents towards which we adopt the intentional attitudes of belief and conjecture. We believe, for example, the proposition that the earth is not flat.[8] Now, on our view, an argument is a proposition of a certain type. This is plausible since any argument can be referred to with an appropriate 'that' clause, and this is precisely how propositions are referred to. For any argument, *R*, we can refer to it as the argument that *R*, and this is precisely how we would refer to *R* if it were a proposition.[9]

When, then, is a proposition an argument? On our view, a proposition is an argument if and only if it consists (just) in a representation of a fact as conveying some other fact. We will say that a proposition represents one fact as conveying another if and only if it represents one fact as, in the circumstances, necessitating or making liable the obtaining of the other.[10] As to facts themselves, they are simply identified with what true propositions represent.[11]

The idea that one fact conveys another has been explicated in terms of the notions of necessitating and making liable. In order to get to grips with these notions note that if, in circumstances *C*, fact *A* necessitates fact *B*, then it is implied that, in circumstances *C*, *A*'s obtaining (i.e. *A*'s being the case) is not possible without *B*'s obtaining. So too, it is implied that facts of the same type as *A* will, in similar circumstances, necessitate, and so invariably be accompanied by, facts of the same type as *B*. As to the notion of making liable, note that, if, in circumstances *C*, fact *A* makes fact *B* liable, then, in circumstances *C*, *A*'s obtaining makes *B*'s obtaining likely.

When one fact conveys another it does so via the obtaining of some relation of conveyance between itself and the fact it conveys. A relation of conveyance is thus any relation in virtue of which, in the appropriate circumstances, one fact necessitates or makes liable another. Relations of conveyance include, among others, *x*'s causing *y*, *x*'s being a member of class *y*, *x*'s being a species of the genus *y* and *x's* constituting *y*. On our view, then, each of these relations can be used in constructing arguments.

Consider, by way of illustration, a case involving the causal relation. In the circumstances, the fact that the US military attacked Iraq caused the fall of Saddam's regime. Thus, in the

[7] The view of arguments we will be outlining here is developed at length in Katzav and Reed (2004).

[8] Notice that we do not identify propositions with atomic propositions that is to say with propositions that cannot be decomposed into other propositions. Anything that might be the content of an intentional attitude, and thus which is a candidate for truth and falsity, counts as a proposition.

[9] The idea that arguments are propositions is an old one. See, for example, Bosanquet's (1888:1–2) related conception of arguments as a species of judgement.

[10] The proposition need not, we emphasize, represent one fact as conveying another and as doing so irrespective of attending circumstances. It need only represent the relation of conveyance as holding in actual circumstances.

[11] In order to avoid unnecessary complications, we are here only outlining a slightly simplified version of our conception of arguments.

circumstances, and via or in virtue of the obtaining of a causal relation, the fact that the US military attacked Iraq necessitated, or at least made likely, the fall of Saddam's regime. Using the causal relation and the above statements about Saddam's regime, we can construct the following simple argument:

(1) Saddam's regime fell, because the US military attacked Iraq and if the US military attacked Iraq, Saddam's regime fell.

In (1), the fact that the US military attacked Iraq is represented as conveying, via the causal relation, the fact that Saddam's regime fell. That the relation of conveyance represented indeed is the causal relation, is implicit in the conditional 'if the US military attacked Iraq, Saddam's regime fell.'

Given this conception of arguments, a propositional theory containing the appropriate background information, and the ability to compute closure over implication, it is possible automatically to determine whether any pair of propositions in the text being considered is such that either (a) one of the propositions in the pair represents a fact which supposedly necessitates or makes liable the fact that is represented by the other, or (b) one of the propositions represents a relation of conveyance which, together with the fact that is represented by the other proposition, supposedly necessitates or makes liable something.[12] Where this is determined, it is possible to conclude that an argument is present in the text. To be sure, eliciting and representing the appropriate information in a knowledge base that might support an implementation of such a system is a huge task. However, it is one that (a) is largely independent of the mechanisms described here and (b) is amenable to approximation by more or less domain-dependent and brittle solutions such as, in the extreme, manual coding (Curtis et al., 2005).

Detecting the presence of an argument within a text by using the above strategy proceeds in one of two ways: it either does or does not involve reasoning. If, for example, a computer system's structured information and theory explicitly contains a pair of propositions and also explicitly contains the information that one of these propositions represents a fact which necessitates or makes liable another in the circumstances, then, upon detecting these propositions in a text, the system can presume immediately (i.e. without reasoning) that it has detected an argument. This, then, suffices to tell us how immediate argument detection is to proceed. If a computer system's structured information and theory does not explicitly represent a text as containing an argument, the computer system will have to determine whether given its embedded information and theory, and given additional information gleaned from the text, it can deduce that the text contains representations of facts as conveying others, thus allowing the (reasoned) conclusion that arguments are present in the text. As already stated, we will discuss how reasoned argument detection is to proceed in section 7.

Before turning to discuss the question of how a computer system is to proceed after immediate argument recognition, we need to say a few more words about the structured information and theory that it must implement if it is to detect the presence of arguments in texts. Since our aim is that the system should be able to reconstruct a text in a way that best captures the intentions of the writer who produced the text, the system ought to embody information and theory that the writer in question is thought to possess. Of course, this does not mean that the system ought to possess every piece of information that the writer possesses. Rather, it is merely to say that it ought to possess the same general background information and commonsense theory needed by

[12] Alternative (b) is needed since it covers cases in which the text only has explicit representations of the relation of conveyance and of the conveying fact.

individuals if they are to understand texts of the kind under consideration—this is the same requirement imposed throughout general natural language processing, and is not specific to argument.

In addition, just as sentences within the text being analyzed must be marked up according to the types of fact they represent, the system's background information and theory must be implemented by marking up sentences in accordance with which types of fact they represent. Such mark-up is essential to reducing the complexity of the tasks involved in argument recognition and reconstruction. For instance, it enables a computer system to avoid going through each explicit argument in its background information and theory in order to determine whether one of these is an argument that represents fact *A*, which is represented by a sentence gleaned from a text, as making liable fact *B*, which is also represented by a sentence from the text. Given that the types of *A* and *B* are known to the system, it need only examine a subset of the explicit arguments it possesses, i.e. those which represent a fact of the same type as *A* as conveying a fact of the same type as *B*.

Similarly, the mark-up of propositions in accordance with the types of facts they represent helps a computer system avoid having to examine each pair of propositions in a text in order to determine whether the text contains an argument from the one to the other. One attributes to a text the assumption that a fact represented by a proposition *p* necessitates or makes liable a fact represented by a proposition *q*, and thus an argument from *p* to *q*, only if it is reasonable to assume that the fact represented by *p* necessitates or makes liable the fact represented by *q*.[13] Moreover, not every type of fact can reasonably be supposed to necessitate or make liable every other type of fact. For example, no fact of pure logic can reasonably be thought to necessitate or make liable any contingent biological fact. Thus, if a computer system implements commonsense theory about which types of fact can reasonably be thought to necessitate or make liable which other types of fact and if the propositions in the text it is considering are marked up as to the types of fact they represent, the system can reduce the number of pairs of propositions it examines by focusing only on those pairs that represent types of fact that are such that it is reasonable to suppose that one of them can necessitate or make liable the other (Reed and Walton, 2005).

5. Enthymeme and possible argument type detection

We focus now on the process of argument reconstruction, proceeding from that stage at which we have detected an argument within a text. The next stages in reconstructing the argument consist in determining whether it is enthymematic and, further, what type of argument it *might* be. Recall, in discussing Kang's argument, we proceeded to determine that the argument contained in the text was enthymematic immediately after having determined that the text contained an argument. The intuition that led us to conclude that the argument was incomplete was that a complete argument ought to describe explicitly how one fact supposedly conveys another fact. Building on this intuition, we can formulate a general criterion for determining whether an argument within some text is complete: a complete argument is one in which the conveying fact, the appropriate relation of conveyance and the conveyed fact are all explicitly represented.

Determining whether a text contains a complete argument should thus be fairly straightforward. Since we are currently investigating the process of argument reconstruction that proceeds from the immediate recognition of an argument within a text, we can assume that

[13] We here employ the charitable principle that the claims implicit in texts are reasonable. It has been argued (Davidson, 1974) that some such principle must be employed in interpretation.

two out of the three facts that are represented by the complete argument are already explicitly represented in the text. Specifically, both the conveying and the conveyed facts are explicitly represented, or the relation of conveyance and the conveying facts are explicitly represented. This is the minimum required so as to allow the system immediately to determine that an argument is represented in the text. But if, in addition to the requisite representation of a pair of facts required for immediate identification of an argument, there is not the third element required in order to constitute an argument, then the system can assume that the argument is incomplete.

If the computer system has determined that an argument is complete, there is, at this stage, no need to examine it further. If, by contrast, it has determined that an argument is incomplete, there are two options. Either the missing component of the argument represents the argument's conveyed fact, or it represents the argument's relation of conveyance. Psycholinguistic evidence suggests that the latter is much more likely (Sadock, 1977), but since the text being considered is appropriately marked up, the system can determine which of these options obtains. If the system finds that the missing component represents the conveyed fact, it can, as we will see in the next section, proceed directly to reconstruct the missing premise. The rest of this section is not relevant to such cases. If it finds that the missing component represents the argument's relation of conveyance, it needs to determine what type of argument the argument *might* be before it can reconstruct this component.

In order to describe how a computer system should go about determining possible argument type, we need to be explicit about what, given our conception of argument, makes an argument an argument of this or that type. An argument, we have suggested, is a representation of a fact as conveying some other fact. Now, we further suggest, what makes an argument the type of argument it is, *is* which relation of conveyance it represents.[14] On our view, arguments are classified in accordance with the types of facts they represent and so in accordance with which relation of conveyance they represent. For example, in the argument expressed by 'Saddam's regime fell, because the US military attacked Iraq and if the US military attacked Iraq, Saddam's regime fell' the relation of conveyance represented is the causal relation. So the argument can be correctly classified as a causal argument.

The component of an argument that determines its type thus consists in a representation of a relation of conveyance. This component, which we will call the argument's warrant, is most perspicuously captured by conditionals of the form 'if x, then (via relation of conveyance r) y', where r is a variable for representations of relations of conveyance, x for statements of conveying facts and y for statements of conveyed facts.

Having clarified what determines an argument's type, we can return to the question of how to determine what type of argument an argument might be in cases where its implicit component represents a relation of conveyance, i.e. in cases where its implicit component is a warrant. Since we know that the missing element is a warrant, we know that both a proposition representing the argument's conveying fact and a proposition representing its conveyed fact will be explicit and marked up as to type. This information allows determining which warrants might be used to infer, together with the statement of the conveying fact, that the conveyed fact is the case.

Consider a statement, p, that represents a fact, A, and a statement, q, that represents a fact, B. On our view, a warrant for inferring q from p states that if p, then (via a suitable relation of conveyance) q. But one should read this warrant into a text only if the warrant is reasonable and

[14] Notice that an argument's type depends on which relation of conveyance it represents rather than on which type of relation of conveyance it represents. (For further discussion of, and for some amendments to, the definition of argument type given here, see Katzav and Reed, 2004.)

so only if it represents a relation of conveyance that can reasonably be supposed to relate facts of the type that *A* is to facts of the type that *B* is. Thus, candidate warrants for inferring *q* from *p* must belong to a class of warrants that represent relations of conveyance that can reasonably be thought to relate facts of the type of *A* to facts of the type of *B*. This is a substantial constraint on which warrant might be used to infer *q* from *p*. No relation of conveyance can reasonably be thought to relate just any type of fact to any other type of fact.

Accordingly, if a computer system gleans from a suitably marked up text that statement *p* represents a fact of the type of *A* and that statement *q* represents a fact of the type of *B*, it can, on our conception of argument type, determine which class of warrants might be used to infer *q* from *p*. In order to do so, it need only implement an adequate theory of which relations of conveyance there are and of which types of fact each such relation can reasonably be thought to relate.

6. Reasoned premise reconstruction

We are now in a position to describe how a computer can go about reconstructing missing premises. Moreover, here too, our conception of argument and argument type will be of assistance. The missing statement we are looking for is either a warrant or a statement describing a conveyed fact. If the missing statement is supposed to describe the conveyed fact, it is easily deduced from the argument's warrant along with the statement of the conveying fact. The warrant describes the appropriate relation of conveyance and what will be conveyed if the conveying fact obtains. Thus, the explicit statement of the conveying fact, along with the warrant, allows the immediate deduction of the implicit conveyed fact. For example, in the argument expressed by 'Saddam's regime fell, because the US military attacked Iraq and if the US military attacked Iraq, Saddam's regime fell', the warrant 'if the US military attacked Iraq, Saddam's regime fell' and the representation of the conveying fact, 'The US military attacked Iraq', immediately imply the representation of the conveyed fact, 'Saddam's regime fell'.

Things are more complex when the missing statement is a warrant. This was the case with Kang's argument. In reconstructing his warrant, we recognised that the conveyed fact represented by his argument was represented by, (a) 'it is hunger that is claiming its victims', and that the conveying fact was represented by (b), 'the district administration is apathetic and the Public Distribution System has failed'. We noted that, given our background knowledge and especially our grasp of the nature of the facts described by (a) and (b), it is fair to conclude that the facts in question are related by some kind of causal dependence. We then expressed this dependence using the causal conditional, 'if the fact described by (b) is the case, then so is the fact described by (a)'. By representing the types of individual propositions, and the ways in which these types can be used in different warrants, it is similarly possible for a computer system to narrow down the set of possible ways in which premises and conclusions might be linked. To guarantee a single solution, further background knowledge would also need to be captured.

Since the system has identified a certain argument as such, we know that it has an explicit representation according to which the argument's conveying fact makes liable (or necessitates), in the circumstances, the argument's conveyed fact. Thus, a statement to the effect that if the conveying fact is the case, it makes liable (or necessitates) the conveyed fact is our first candidate for being the argument's warrant. However, the weak justificatory strength of warrants that represent the very abstract relations of necessitating or making liable means that such statements are not likely to be used in justifying claims. In the case of Kang's argument, for example, it was clear that our reason for thinking that the fact described by (b) makes the fact described by (a) liable in the circumstances was our realising that the two facts are (supposedly) causally dependent.

The computer system ought, then, to seek a warrant that represents a more concrete relation than that which it can already assume the argument uses, i.e. it ought to seek one that represents neither the relation of making liable nor that of necessitating. Specifically, it ought to seek a warrant that represents a more concrete relation that supposedly obtains (i.e. that relates supposedly actual particulars or properties) and that, further, is compatible with one of the types of argument that the argument under consideration might be (i.e. that can be represented by one of the types of argument that the argument under consideration might be). Only if the attempt to uncover a warrant that represents a more concrete relation of conveyance fails should the computer system conclude that the already available candidate warrant is the best candidate for being the argument's warrant.

How is the computer system to determine whether its background information and theory implies a warrant that might be used by a given argument and that represents an appropriately concrete relation of conveyance? At this stage in the process of argument reconstruction, the system has gone through the process of possible argument type detection, and so has used its information about which relations of conveyance there are and about which types of fact each relation of conveyance might reasonably be thought to relate, in order to select a class of possible warrants for the argument it is considering. In addition to information about the class in question, the system's background information should include statements of the facts typical individuals are familiar with, statements which are marked up so as to indicate which types of fact they represent, and thus which (if any) relations of conveyance they supposedly represent and which types of fact each supposed relation of conveyance supposedly relates. This information can be used to guide and reduce the process of determining whether the computer's information and theory implies that if the conveying fact that the argument represents obtains, then, in virtue of a suitable relation of conveyance, so too does the conveyed fact it represents (Reed and Walton, 2005).

Here is an example of how the mark-up of background information according to the types of facts they represent constrains the process of selecting a suitable warrant. Assume that a computer system is trying to deduce '*Rab*' (i.e. the claim that fact *a* conveys, via relation *R*, fact *b*) from its background information and theory, and thus to determine whether a warrant representing *R* can be used to argue from the claim that *a* to the claim that *b*. '*Rab*' itself represents a fact of a certain type, one the system knows can only reasonably be supposed to be related by some relations of conveyance to some types of facts. Thus, the system need not examine what follows from each piece of background information it has in attempting to deduce '*Rab*'. It can focus solely on pieces of background information that represent types of facts that can reasonably be supposed to be related to '*Rab*'.

Of course, the computer system might discover more than a single viable candidate warrant that represents a relation of conveyance that is more concrete than those of necessitating or making liable. If it does, it should pick that candidate which represents the most concrete of the relations of conveyance that are represented by the viable candidate warrants. Our assumption here is that the information the computer system possesses about which relations of conveyance there are is supplemented by information about their relative degrees of abstraction.

In requiring that the computer system seek a warrant that represents a more concrete relation than those of making liable or necessitating, we are reiterating our commitment to a minimalist programme of warrant reconstruction. Seeking a warrant that represents a more concrete relation of conveyance means seeking one that is less general and so less risky. At the same time, the use we are making of mark-up shows how our minimalism is constrained by fidelity to the text.

The text carries information about the types of the conveying and conveyed facts represented by the argument, and this delineates the class of candidate warrants for the argument by delineating the class of relations of conveyance which might be represented by its warrant. Background information further helps to narrow down the class of warrants by allowing the system to determine which relations of conveyance are actually supposed to relate the conveying and conveyed facts. It is among warrants that represent these remaining relations of conveyance that the computer system selects the one that is the most concrete.[15]

Let us illustrate our approach to reasoned warrant detection by considering Kang's argument once again. The warrant we surmised it used was something like, 'if the district administration is apathetic and the Public Distribution System has failed, then this will cause hunger to claim its victims'. How might a computer system reach the conjecture that this is the missing warrant in Kang's argument? The system is already working under the assumption that Kang's argument is of one of a number of types, that is to say that is uses one of a number of relations of conveyance. Moreover, one of these relations is that of causal dependence. Thus, if it has or can deduce a suitable statement of causal dependence, it will have a good candidate for the role of missing warrant. Consider, then, the following two statements:

(1) The people in Baran cannot feed themselves.
(2) If people cannot feed themselves and government cannot feed them, hunger will claim its victims.

Statement (2) is a statement of causal dependence. Moreover, it is plausible to suppose that something like it is explicitly among the causal statements represented in a reader's background theory. Thus, let us assume that (2) is appropriately marked up among the background theoretical statements of the computer system we are envisaging. Since (2) is marked up as a statement of causal dependence, and thus as being compatible with one of the types of argument that Kang's argument might be, the computer system should take it to be a statement from which an appropriate warrant for Kang's argument might be deduced. That it is such a statement is further confirmed by seeing that the types of facts it represents as being related by the relation of causal dependence include the types of facts that are represented by the explicit premise and conclusion of Kang's argument. The system must, accordingly, try to deduce a viable candidate warrant from (2) along with additional suitable background information (that is to say from (2) along with other statements marked up as statements that represent types of facts that (2) represents as being related by the relation of causal dependence). Assuming that the computer has (1) among the statements that make up its background information, it will be able to deduce a statement of the conveyed fact, namely of the fact that hunger is claiming its victims, from (2) along with (1). With this success, it can conclude that (2) along with (1) immediately entail a good candidate for the role of warrant for Kang's argument. In other words, it can conclude that a good candidate for the role of warrant for Kang's argument is that, in the circumstances, if the government does not feed them, hunger will claim its victims. The computer system can then compare this conditional with other good candidates it has uncovered and choose the one that represents the most concrete relation of conveyance.

[15] There is a wide range of techniques for warrant reconstruction advocated in the literature, from the parsimonious to the profligate, as well as positions between (see, e.g. Hitchcock, 1985; Ennis, 1982; Gilbert, 1991). Implementing these different techniques is merely a matter of changing the rule for selecting which of the set of warrants that are compatible with the text and with the computer system's background information should be selected by the system.

7. Reasoned argument detection

The above concludes our discussion of immediate argument detection, that is to say cases of argument detection in which a system already explicitly represents the conveying fact of an argument as necessitating or making liable its conveyed fact, or in which a system explicitly represents the conveying fact and the relation of conveyance of an argument. What remains is to consider how a computer might detect and reconstruct an argument where immediate recognition is not possible.

If a computer system considers a pair of propositions, p and q, from a text, it can attempt to deduce, from its background information and theory, a warrant according to which if p, then (via a suitable relation of conveyance) q. The process of doing so is identical to the process of warrant identification already described in our discussion of reasoned premise reconstruction. If a suitable warrant is uncovered, this process will not only tell us that there is an argument in the text, but will also yield a complete reconstruction of the argument in question.

If the propositions being considered do not represent conveying and conveyed facts, they may yet turn out to be components of an argument if one of them represents a conveying fact and the other a relation of conveyance. In such cases, determining whether two propositions represent an argument is just a matter of determining whether one of them states that facts of the type that are represented by the other convey something. The mark-up of propositions as to the types of facts they represent and the system's information about relations of conveyance should suffice immediately to determine this.

8. A model of argument recognition and reconstruction

We now offer, in Fig. 2, a complete, if abstract, architecture of the argument reconstruction process.

The process begins with statement reconstruction. It then proceeds to deal with all those arguments that can be immediately detected. This part of the process proceeds until the stage of text modification, that is to say that stage at which the original text might be modified by adding to it missing premises the computer system has uncovered. Once the stage of text modification has been seen to, the computer system proceeds to examine whether additional immediate arguments are detectable in the text as a result of the text modification. If such arguments are detectable, the process of immediate argument reconstruction is carried out again on the additional arguments. If no additional arguments are immediately detectable, the computer system proceeds to the stage of reasoned argument detection. Here too, the process proceeds until the stage of text modification, and then returns to the stage of immediate text detection. If no additional arguments are immediately detectable and, then, no additional arguments are detectable by reasoning, the process terminates.

9. Implementation

With this architecture in place, it becomes possible to identify modular components that can be investigated relatively independently. In a sense then, Fig. 2 represents both a large-scale programme of work and a means of integrating the component results of that work. For some areas, extant results and implementations can be re-used; in others, new theoretical or empirical research is required; and in yet others, implementation is more readily pursuable.

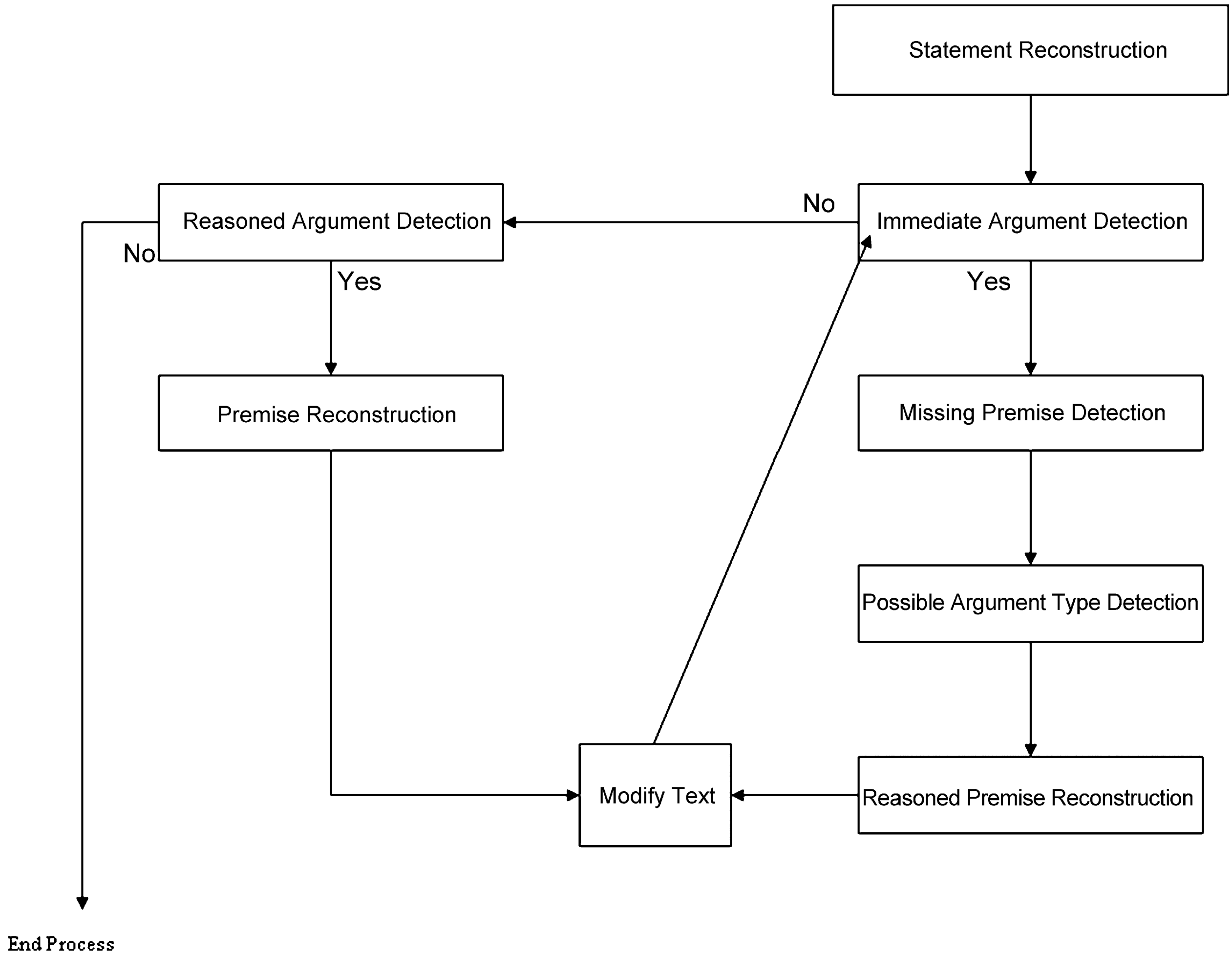

Fig. 2. The architecture of the argument reconstruction process.

A theory of argument types has been developed that is founded upon the notion of argument summarised here (Katzav and Reed, 2004). A system for representing the knowledge constituted by such arguments is available and mature, inasmuch as it is being harnessed in a wide variety of domains such as engineering, pedagogy and the law (Reed and Rowe, 2004). The representation of types of fact, types of argument and relationships between types of fact has been implemented as a means of "stratifying" knowledge databases, and has been employed to improve communication between autonomous software agents (Reed and Walton, 2005). In summary then, the mechanics of representing partially analysed arguments and background knowledge, and the process of stratified reasoned argument reconstruction are currently in place.

10. Conclusion

The process of argument recognition and reconstruction we have outlined clearly suffers from a number of limitations. For example, it does not deal with the reconstruction of arguments in which the implicit premise represents a sequence of relations of conveyance rather than a single relation of conveyance. So too, it is arguable that our notion of argument is not sufficiently general. Thus, it may be argued that some arguments have questions as premises and conclusions, something we have not allowed for. No doubt, there are additional limitations to our model. Nevertheless, we believe that a significant degree of success can be achieved by implementing the model as its stands and, moreover, that the strategies that it employs are sufficiently flexible so as to allow the model to function as a foundation upon which future work can build in harnessing results from argumentation theory in practical systems that directly implement models of the pragmatic structure of argument. We have shown how a programme of work in building computational systems that handle argument can be undertaken to a large extent independently of the more fine-grained issues of computational semantics and sentence understanding, thereby allowing theories of argument structure to be harnessed in developing implemented models of argumentative linguistic behaviour.

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