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The Art of Finding Arguments

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Kienpointner (1997) showed how the ancient status theory and the Aristotelian theory of topics are parts of an art of argument invention that selects premises to be used in a chain of argumentation from a database of premises accepted by the audience a speaker is trying to persuade. He showed how pursuit of this art of finding arguments, although discredited in the Enlightenment, has recently has been taken up again by argumentation theorists. In this paper it is shown that with the recent advent of computational argumentation systems in artificial intelligence, a technology is now available to help an arguer to find arguments that support her claim, and to refute counter-arguments opposing her claim.

The origins of attempts to build a systematic method of finding arguments to persuade an audience to come to accept some proposition they were doubtful about or even disagreed with can be found in ancient Greek philosophy and rhetoric. The tradition persisted through the Middle Ages, but was severely criticized by Antoine Arnauld in the 17th century. He claimed that only good knowledge of the subject is needed for finding arguments, and that no special technique of the kind employed by Aristotle and the ancient rhetoricians is required (Kienpointner, 1997, 228). This approach was called by Kienpointner (1997, 230) "encyclopedic". Nowadays people who accept this view might think that the best way of finding arguments is on the Internet by using resources like Google, Wikipedia and Debatepedia.[1] On this view, all that matters are "the facts". At the opposite extreme of the encyclopedic approach, creativity techniques such as "brainstorming" impose hardly any restrictions on the finding process: all ideas are welcome and no criticism is allowed (Kienpointner, 1997, 231). This paper shows the way toward finding a middle way to go forward between these two extremes.

In this paper it is shown that we are entering a new era in which technologies for helping a user to find arguments to persuade an audience will be made possible by new computational argumentation systems currently being built in artificial intelligence. Sections 1 and 2 present the historical background of the art of finding arguments, based on the survey of (Kienpointner, 1997). In section 3 it is shown how the general framework on which such systems are being built is basically that of knowledge-based systems, such as the early expert systems developed in artificial intelligence. It is shown how such artificial intelligence systems provide a framework in which propositions accepted by an audience can be used as a knowledge base to move a chain of argumentation forward towards the ultimate conclusion to be proved by an arguer. In section 4 a simple example about the issue of whether Wikipedia is reliable is used to illustrate the fundamentals of how such a system of argument invention works to find new argument to strengthen a line of argumentation to support an arguer's claim. Section 5 provides a slightly more complex example in which it is shown how a given argument put forward by a proponent can be attacked successfully by an opponent who casts around for new argument used for this purpose. Then it is shown how the proponent can use the same technique of argument invention to find new argument to attack the argumentation of his opponent. Section 6 briefly outlines three recent computational argumentation systems that have the capabilities required to build an argument invention system of the kind described in the previous sections. Section 7 presents conclusions suggested by these findings.

[1] Debatepedia has a database (http://idebate.org/debatabase) of written debates with facts and examples both for and against on hundreds of issues.

1. The Role of Topics in Argument Invention

Kienpointner (1997, 226-232) presented a historical survey showing that work on argument invention started in the ancient world, and over the centuries even though it has had its ups and downs, has continued to be a subject of investigation and interest. The Greek philosophers and rhetoricians had a good deal to say about argument invention, and it is even fair to comment that they were already aware of how a system for finding argument should work in general outline. It is well known that Aristotle had listed a set of so-called topics (*topoi*), representing places where arguments can be found, that are the basis of his system for argument invention. According to Kienpointner (1997, 227) Aristotle listed 300-400 topics in his *Topics* (Aristotle, 1939), but authors on Roman rhetoric reduced them to about 20-30 types of arguments. These so-called topics, nowadays called argumentation schemes (Kienpointner, 1992), can be used to evaluate arguments by fitting them to the topics. Aristotle showed that they also have a search function that can be used to guide an arguer to find arguments to support the conclusion he advocates. Over the centuries, some authors emphasized the search function while others viewed the evaluation function as more important (Bird, 1962). The tradition of the topics continued through the Middle Ages, but in the seventeenth century it was severely criticized by Antoine Arnauld in his treatise *La Logique, ou l'Art de Penser* (Kienpointner, 1997, 228).

As Kienpointner (1997, 226) describes them, topics are forms of argument that validate the inferential transition from premises to conclusion in an argument. Topics have two functions. First, they can be used to validate arguments by showing that the argument fits the structure of the scheme. The term 'validate' can be used here as referring to deductive forms of argument, but it can also be used in a wider sense that includes defeasible forms of argument that may not be either deductive or inductive in a narrower sense referring to statistical arguments. Second, they can have a search function. The search function enables an arguer to search in a database to try to find arguments that can be used to prove some designated conclusion. This second task is called the art of finding arguments by Kienpointner and was also called argument invention in the traditional literature in antiquity and medieval times. As Kienpointner describes it (1997, 226) the search function helps an arguer select arguments that have premises accepted by the audience to whom the argument is supposed to be directed. In particular, the traditional literature cited the importance of propositions that are generally accepted, that is that are "accepted by all or most people and all or most experts" (Kienpointner 1997, 226).

As his example Kienpointner (1997, 226) cites a discussion about nuclear power stations. There are several different kinds of arguments you might search out in order to persuade your audience that having nuclear power stations is a good or bad idea. You could point out positive or negative consequences of using atomic power stations. Here you would be using the schemes for argument from consequences, which has two forms (Walton, Reed and Macagno, 2008, 332), argument from positive consequences and argument from negative consequences. Using argument from positive consequences, a recommended course of action is supported by citing favorable consequences. *A* is an action or policy being considered.

Major Premise: If *A* is brought about, then consequences *C* will occur.
Minor Premise: Consequences *C* are good.
Conclusion: Therefore *A* should be brought about.

Using argument from negative consequences, a course of action recommended by an opponent is attacked by citing negative consequences

Major Premise: If *A* is brought about, then consequences *C* will occur.
Minor Premise: Consequences *C* are bad.
Conclusion: Therefore *A* should not be brought about.

Both forms of argument are defeasible, meaning that each of them leads tentatively to its conclusion, which is subject to later retraction if new evidence comes in from consequences. Each form of argument can be attacked by the asking of critical questions. Another form of argument that might be used in the nuclear power example, according to Kienpointner, would be to compare the costs and efficiency of nuclear power stations.

A third form of argument cited in Kienpointner's example would be to quote scientific experts who made statements about nuclear power stations. Here you would be using the scheme for argument from expert opinion (Walton, Reed and Macagno, 2008, 310).

Major Premise: Source *E* is an expert in subject domain *S* containing proposition *A*.
Minor Premise: *E* asserts that proposition *A* is true (false).
Conclusion: *A* is true (false).

This form of argument is defeasible as well, and can be attacked or even defeated by the asking of appropriate critical questions.

Whichever side you are on, you can select the arguments that support the conclusion that you have chosen. Applying argumentation schemes can help you find some of these arguments, and also to find additional premises needed in these arguments. But that is not the end of the art of finding the arguments needed to support your ultimate conclusion. You will need to chain your arguments together, combining them to make the strongest case you can for the conclusion you advocate on the nuclear power issue. You will also need to look for gaps in your chain of argumentation so you can try to fill them in order to prove your ultimate conclusion to the satisfaction of the audience you are addressing.

2. Kienpointner's Historical Survey

Kienpointner's description of how this search function works in the Aristotelian framework shows how the search mechanism looks for propositions that are accepted by the audience an arguer's argument is designed to persuade, so that these propositions can be used as premises in the argument he is trying to build. Kienpointner describes it this way: "The search formulas help to select relevant arguments from the set of 'endoxa', that is, the propositional content of the arguments has to be taken from the set of propositions which are accepted by "all or most people and or by all or most experts". This generally accepted set of propositions would nowadays be called common knowledge. So described, the way a system of argument invention works requires two components. One is a set of arguments made up of premises and conclusions. Presumably these arguments will be linked up into a network or chain of argumentation aiming towards the ultimate conclusion that the arguer wants to get the audience to come to accept, even though they do not accept it now. The other component is that the premises used in these arguments need to be propositions that the audience accepts, or perhaps can be brought to accept through further argumentation. Acceptance is also associated with the notion of commitment in the argumentation literature (Hamblin, 1970; Walton and Krabbe, 1995).

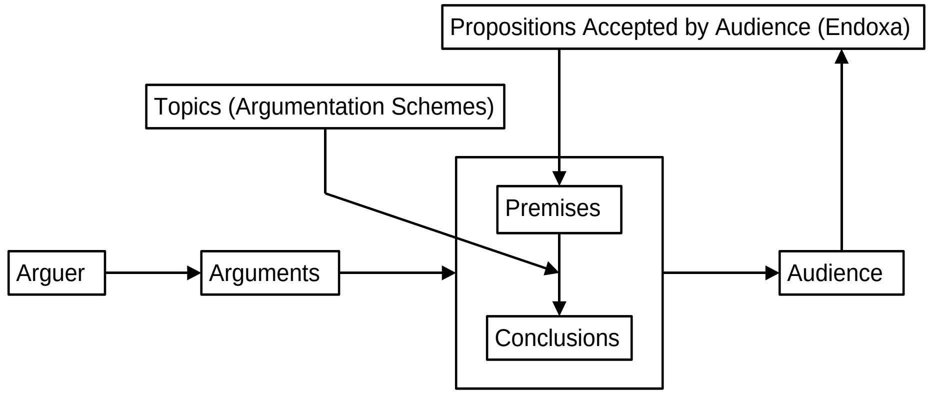

Figure 1: Persuasion Based on Premises Accepted by the Audience

What the Aristotelian tradition seems to have primarily in mind, at least in connection with rhetorical argumentation, is that the arguer is trying to persuade his audience to come to accept some proposition that it was not previously inclined to accept. Seen this way, in order for persuasive argumentation to be successful, it needs to be based on premises that are accepted by the audience (Bench-Capon et al., 2007). This is the most fundamental characteristic of persuasion dialogue. The argumentation used in it, in order to be successful, must always be based on premises accepted by the party who is the target of the act of persuasion.

Kienpointner emphasizes the role of the *endoxa*, the set of propositions accepted by all or most people and/or the experts. This set of propositions represents common knowledge of the kind that would not be disputed by anyone in a general audience. These are propositions like ‘Sharp knives can be dangerous’ and ‘Smoking is unhealthy’. But a very important aspect of the success of arguments designed to persuade is that they need to be based on what is accepted by a specific target audience. An argument put forward by a politician in an election needs to be carefully fitted to what the arguer takes to be the political commitments of the audience he or she addresses. If the audience is known to be partisan, the kinds of arguments needed to persuade them need to be based not just on common knowledge, but as well on premises that this particular audience can be taken to accept. An argument addressed to participants in a physics seminar on the subject of nuclear magnetic resonance will need to be based on accepted premises of a very different sort from an argument put forward by an attorney in a trial. This audience centered characteristic of persuasive argumentation is vitally important in the study of the art of finding arguments (Tindale, 1999).

Another device that was very important for the ancient art of finding arguments is the status theory developed by Hermagoras of Temnos in the second century BC (Kienpointner, 1997, 228). In this theory, in order to find arguments, you have to identify the issue. For example, two parties may be having a debate about whether Wikipedia is reliable. The one side may take the view that Wikipedia is reliable, and present pro arguments supporting this claim. The other side may take the view that Wikipedia is not reliable, arguing that it is too open to error to make it be reliable. The status is the issue, that is, the two opposed opinions and the relationship of opposition between them. According to the status theory, each side has a proposition or claim that it is supposed to prove by marshaling arguments that support its own claim and attack the claim of the other side. To put a different way, each side has an ultimate probandum, or proposition to be proved. According to the status theory, it is the relationship of any particular argument to this ultimate probandum that determines whether the argument is relevant in the debate.

Status theory is clearly at work in the kind of legal argumentation one sees in a trial in the common law setting. It is an adversarial procedure where each side has its ultimate *probandum* and the *probandum* of the one side is opposed to that of the other. Different kinds of opposition are recognized. If the one proposition is the opposite or negation of the other, that is said to represent a strong kind of opposition. If one side has a positive *probandum*, and the other side is merely skeptical of that *probandum*, but does not have a positive *probandum* of its own, that is said to represent a weak kind of opposition. As Kienpointner showed (1997, 229), status theory is closely related to modern debate theory. Both approaches specify a central issue that has to be identified when evaluating an argument, and emphasize that a given argument needs to be evaluated within a network of argumentation that aims toward proving or disproving some ultimate proposition at issue. This framework can be viewed as an inverted tree structure. The ultimate conclusion to be proved is the root of the tree and the branches leading to the root of the tree represent a network of interlocking arguments. Such a network is formed on the basis that a conclusion of one argument can be a premise in another successive argument.

3. How AI Systems Can be Adapted to the Task of Finding Arguments

A knowledge-based system of the kind used in artificial intelligence has two components, a knowledge base and an inference engine. The knowledge base represents facts about the world, and can be thought of as a set of propositions. The inference engine is used to draw inferences from the factual propositions, and is typically represented as a set of If-THEN rules. The earliest knowledge-based systems were rule-based expert systems. For example, Mycin, a program for medical diagnosis, represented facts as propositions in a database, and used rules to generate new propositions as conclusions derived from the facts. As artificial intelligence developed as a field, knowledge bases became more structured so the relations between classes, and other kinds of relations permitted different kinds of inferences to be drawn from the knowledge base.

It is well-known that knowledge-based systems and other useful systems developed by artificial intelligence research enable the system to search through a large database and to chain premises and conclusions drawn from the database to derive some conclusion that is the object of inquiry. Until very recently, the use of such tools in artificial intelligence has not been directed to building a system of argument invention. However one can easily see from Kienpointner's (1997, 226) description of how the ancient art of finding arguments was supposed to work that structures commonly used in artificial intelligence could be applied to this task. According to his description of the Aristotelian search formula designed to find arguments, the knowledge base would correspond to a set of propositions accepted by the audience to whom the argument is directed, and a set of inference rules of the IF-THEN kind could be associated with the topics, or forms of argument used to draw inferences from premises to conclusions.

Figure 2 shows how the Aristotelian method of finding arguments can be configured as a species of knowledge-based system of the kind used in artificial intelligence. The knowledge base is composed of a set of propositions accepted by the audience. This would generally be quite a large set composed of propositions that can be taken for granted in an argument as common knowledge as well as propositions unique to the specific audience the arguer is addressing. Just as in a modern knowledge-based system, inferences are drawn from subsets of this large set of propositions using argumentation schemes (topics) as inference rules enabling a conclusion to be drawn from a set of premises accepted by the audience.

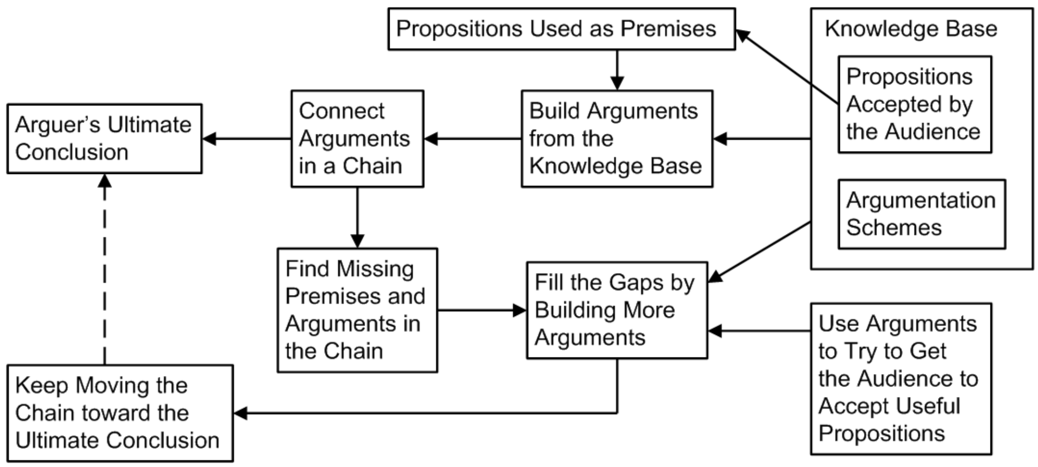

Figure 2: An AI System Finding Arguments from a Knowledge Base

To be used for purposes of argument invention, the scheme must also have the capabilities of (1) connecting together arguments drawn from the knowledge base and chaining them forward in sequences of argumentation, and (2) locating the missing premises and arguments in a chain of argumentation that are needed to move the chain of argumentation forward towards the other arguer's ultimate conclusion to be proved to the audience. The general idea is to keep the chain of argumentation moving forward, filling the gaps in it along the way, so that the target of the procedure is to arrive at the ultimate conclusion. Such a sequence of argumentation might either show that the ultimate conclusion can be proved, or it might show that it is not possible to prove it from the knowledge base unless additional assumptions are added. Both findings would be extremely useful to an arguer who is trying to persuade an audience to accept some particular proposition they currently have doubts about, or are even opposed to.

It is possible to give a general outline of how such a system would work by outlining an abstract example showing how the procedure of finding an argument needs to be built around a chain of argumentation of this sort. In the example structure shown in figure 3, C represents the arguer's ultimate conclusion to be proved to the audience. It is assumed to be a proposition that the audience does not presently accept. The goal of the arguer is to build up a sequence of argumentation where all the component arguments required to prove the ultimate conclusion are propositions that the audience currently accepts. As well the sequence of argumentation will include premises and conclusions that are propositions that the audience does not presently accept. It is legitimate for these propositions to be represented, because it is very useful for an arguer to come to know what parts of the argument he needs to concentrate on, and to try to support by finding new arguments that are presently not accepted by his audience. Below some simple examples of real arguments will be given, but for the moment it is important for the reader to get a general idea of the outline of a structure of a system for finding arguments that is comparable to the kinds of structures we are familiar with in knowledge-based systems of the kind used in artificial intelligence.

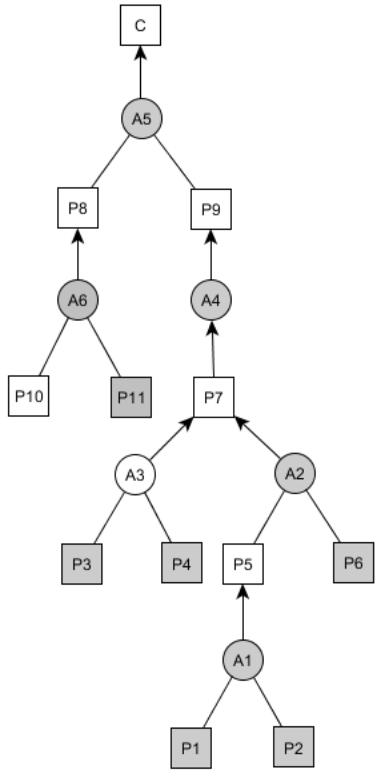

Figure 3: The Structure of an AI System for Finding Arguments

As shown in Figure 3, the system constructs a chain of argumentation made up of six arguments labeled A1 to A6 in the argument diagram. Each argument is based on one or more premises, and these premises are labeled as propositions P1 to P9 in the argument diagram. If you look over the sequence of argumentation as a whole, the six arguments are all connected together as a chain of reasoning that moves towards the ultimate conclusion C. The premises that are accepted by the audience at the beginning of the argument (P1, P2, P3, P4, P6 and P11) are shown in darkened boxes. The premises that are not accepted by the audience (P5, P7, P9, P8 and P10) are shown in boxes with a white background. The conclusion C, not accepted by the audience, is shown in a box with a white background. The arguments that are valid are shown in darkened round argument nodes. Any argument that is not valid (A3 is the only one) is shown in a round node with a white background.

The term 'validity' used in this context can have two different meanings. First it can refer to a deductively valid argument, an argument in which it is logically impossible for the premises to be true and the conclusion false. With a deductively valid argument, if the premises are accepted, the conclusion also has to be accepted by the audience. But validity can also refer to a defeasibly valid argument, defined as an argument that fits a defeasible argumentation scheme. Defeasible arguments are subject to defeat if new premises are added to them. With a defeasible argument, if the audience accepts the premises, then it also has to accept the conclusion, but only tentatively. If the audience can ask critical questions showing that the defeasible argumentation does not apply in a given case, for example if there is an exception to the rule that is the basis of the inference, then it does not have to accept the conclusion even though it accepts the premises.

Nevertheless in the normal case, in the absence of such counter-considerations shown by the arguer, if the audience accepts the premises, and a defeasible argumentation scheme applies to the argument, then it has to at least tentatively accept the conclusion as well.

With this information in hand, let us examine the chain of argumentation shown in figure 3, starting from the bottom and proceeding to the top. Since both premises P1 and P2 have been accepted, as shown by their darkened boxes, and since argument A1 applies (is valid), the audience has to accept P5. For this reason, P5 should is automatically shown in a darkened box. Next let's examine arguments A2 and A3. A3 is not a valid argument. Therefore, even though both of its premises P3 and P4 are accepted by the audience, the audience does not have to accept P7 on this basis. However, let's look at argument A2. P6 was already accepted by the audience at the beginning, and now it had to accept P5 as well because A1 is a valid argument and the audience accepted both of its premises. Therefore the audience has to accept P7, and P7 should now be shown in a darkened box. Next, P9 obviously needs to be shown in a darkened box, because argument A4 is valid, and its only premise P7 has to be accepted by the audience.

Next let's look at argument A5. A5 is a linked argument, meaning that both premises P8 and P9 have to be accepted if C is to be proved acceptable to the audience. The audience now accepts P9, but it does not accept P8, indicated by P8's appearing in a white box. Thus as things stand the audience has not yet been persuaded to accept C. Thus the only thing the arguer needs to do in order to rationally persuade the audience to accept C is to persuade the audience to come to accept P8. But there is an argument that has been put forward for P8, argument A6 with premises P10 and P11. The problem here is that even though P11 has been accepted by the audience, P10 is not accepted.

Given this situation, how should the arguer look around to try and find arguments that can be used to prove C? What strategies of argument invention are available? There are two moves available. The first move is to try to find an argument that would persuade the audience to accept P10. If P10 were accepted, then since P11 is already accepted and argument A6 is valid, P8 is automatically accepted by the system. Now both P8 and P9 are accepted, they can be shown in darkened boxes. Since both premises of the linked argument A5 are now accepted, and A5 is valid, the conclusion C is now accepted and can be shown in a darkened box. The second move is to search around for some new argument, other than A6, that can be used to prove P8.

4. A Simple Example

In this example, the arguer's ultimate conclusion to be proved is the statement that Wikipedia is reliable. As shown in figure 4, the audience does not accept this proposition. The argumentation beneath the ultimate conclusion shows why. There are two arguments. The one on the left is a supporting argument for the claim that Wikipedia is reliable. It is based on two premises. The audience accepts the proposition that Encyclopaedia Britannica is reliable. However it does not accept the other premise, stating that Wikipedia is as reliable as Encyclopaedia Britannica. Hence this argument is not persuasive.

The argument shown on the right is a counterattack, an argument against the conclusion that Wikipedia is reliable. In this chain of argumentation, the statement that Wikipedia is subject to errors is supported by argument A2, and the audience accepts both premises of this argument. Moreover the audience accepts the argument is structurally valid, as indicated by the darkened node containing A2.

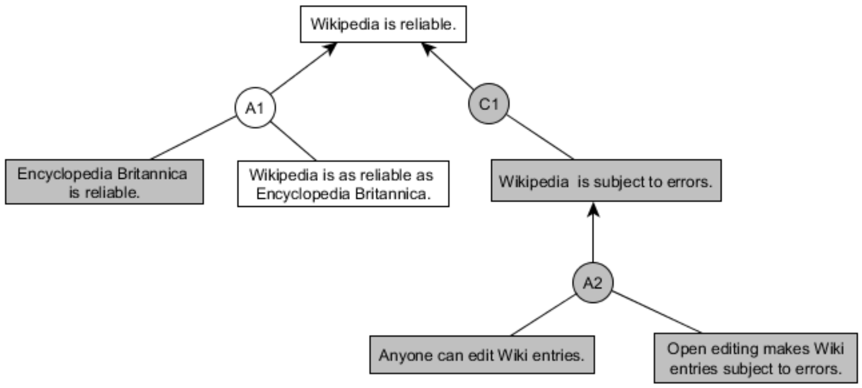

Figure 4: Initial State of the Wikipedia Argument

Hence this is a persuasive argument, and by reason of it, the audience accepts the conclusion that Wikipedia is subject to errors. But then to follow the argument upward, the statement that Wikipedia is subject to errors, now accepted by the audience, provides a persuasive counterargument attacking the conclusion that Wikipedia is reliable. Hence the argument shown on the right offers a reason for the audience not to accept the conclusion that Wikipedia is reliable even though they did not accept it anyway, based on the argument on the left.

What could a system of argument invention recommend in order to remedy the defects of this argument and make it successful to persuade the audience to accept the conclusion that Wikipedia is reliable? Two actions, either of which could be taken to fix the argument to achieve this goal are shown in figure 5.

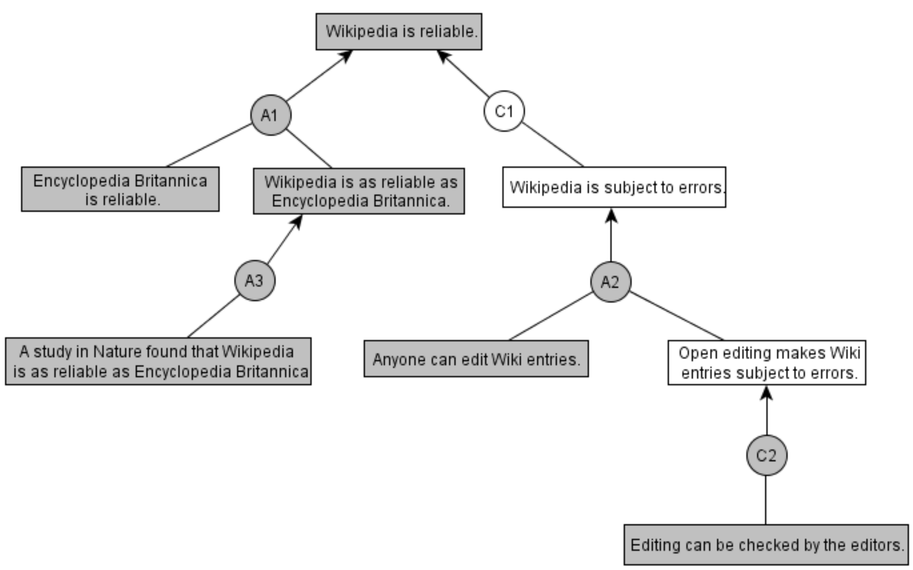

Figure 5: The Invention System Finds some New Arguments

First, if we look on the left side of figure 5, the system has searched around in its database and found a proposition that can be used as a premise in an argument that would support the accepted statement that Wikipedia is as reliable as Encyclopaedia Britannica. This statement says that a study in *Nature* found that Wikipedia is as reliable as Encyclopaedia Britannica. It has been shown in a gray box, indicating that the audience finds it acceptable. It has been inserted as a premise in argument A3. This new argument has now supported the premise above it previously shown in a white box, stating that Wikipedia is as reliable as Encyclopaedia Britannica. Once this premise has been accepted by the audience, it goes along with the other premise of argument A1, and now the chain of argument on the left offered to the audience is sufficient reason to accept the ultimate conclusion that Wikipedia is reliable.

The second action that could be taken is to counter-attack the argument shown on the right in figure 5. The way for an argument invention system to do this is to find a counterattack to the original counterattack C1. This could be done as shown on the right side of figure 5. The system could do this by finding the statement that editing can be checked by the editors in its database of propositions that the audience accepts. It then uses this premise in a new argument C2 to attack the previously accepted premise that open editing makes Wiki entries subject to errors. Now that one of its premises is not accepted by the audience, A2, even though it remained structurally valid, is insufficient to make the audience accept its conclusion that Wikipedia is subject to errors. Hence this statement is now shown in a box with a white background. For this reason, counterattacking argument C1 is inadequate to defeat the ultimate conclusion that Wikipedia is reliable. Hence now we have a situation where there is a supporting argument on the left proving the ultimate conclusion to the audience, and a counterattack argument on the right that has been defeated by the new arguments found by the invention system.

Without the second invention action having been taken, there would be a deadlock. Both the pro and the con argument would be persuasive. But with both actions taken, the pro argument is persuasive while the con argument is knocked out of contention.

5. A More Elaborate Example

Another slightly more elaborate example can be used to show how an argument invention system could be used in a sequence of two steps. In the first step, it takes an argument that is successful in persuading its audience to accept the conclusion and shows how to defeat it by constructing counterargument strategies built on its database of propositions accepted by the audience. In the second step, it shows how to overcome the counterattacking argument.

Two arguments are shown in figure 6 supporting the ultimate conclusion that building nuclear power plants in Europe is a good idea. This argument could be part of the debate on whether building nuclear power plants in Europe is a good idea, one side claiming that it is a good idea while the other side claims it is not. Each of the two arguments is valid, and each of them has two premises that are accepted by the audience. So this argument, as it stands, is persuasive to the audience. Given that the audience accepts the two premises of each of the two arguments, and that the two arguments A1 and A2 are valid, it can be inferred that the audience accepts the conclusion. Hence the conclusion, the proposition that building nuclear power plants is a good idea, is shown in box with a grey background. But suppose that the arguer wanted to find some arguments that would attack his argument? Or suppose his opponent wanted to find such arguments?

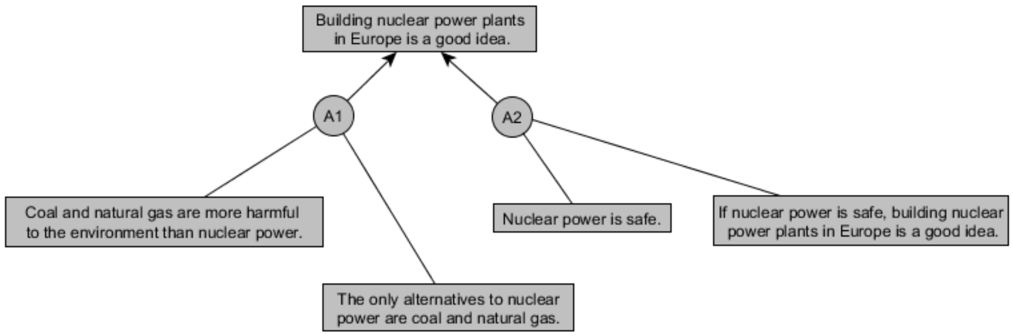

Figure 6: The Initial State of the Nuclear Power Example

How could an argument invention system look around to find some new arguments that would attack this original argument?

If possible it would be good if the system would suggest ways to attack both arguments. How this could be done is shown in figure 7.

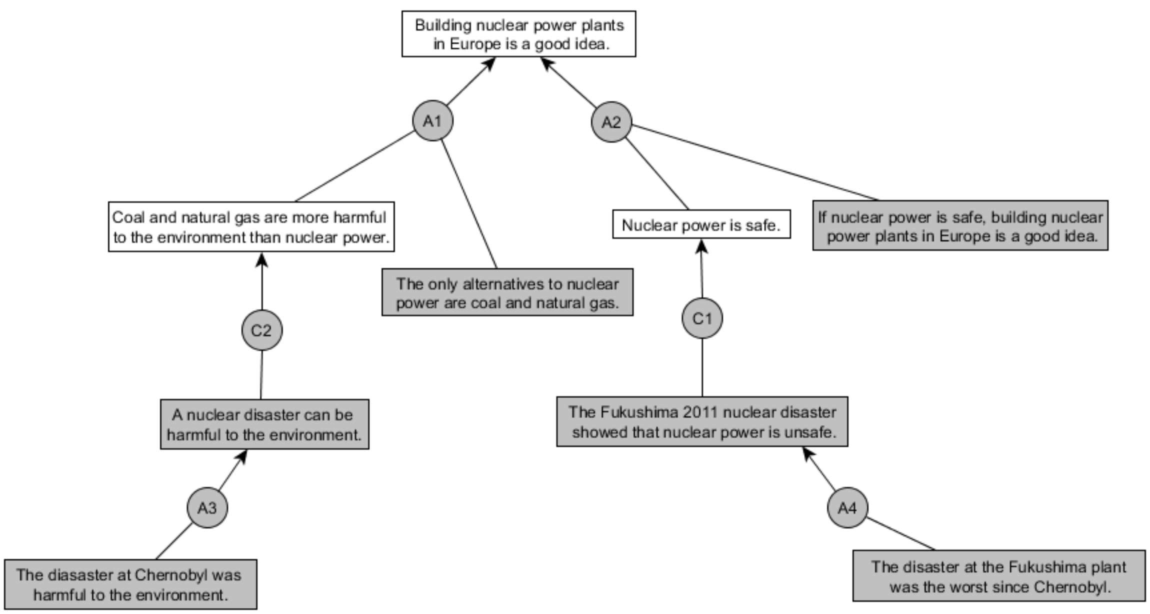

Figure 7: New Arguments Found in the Nuclear Power Example

The argument on the left, A1, is attacked by a counterargument based on the premise that a nuclear disaster can be harmful to the environment. This statement is supported by another one that is found in the database of propositions accepted by the audience. It is the proposition that the disaster at Chernobyl was harmful to the environment. Both these propositions are clearly acceptable as common knowledge of the sort that would not be likely to be challenged. Thus once the invention system has found these propositions and use them in arguments A3 and C2, argument A1 is defeated, since one of its premises is no longer acceptable to the audience. Next we turn to the argument on the right. The argument invention system searches around in its database of propositions accepted by the audience and finds two propositions. One is the statement that the Fukushima 2011 nuclear disaster showed that nuclear power is unsafe. The other is the proposition that the disaster at the Fukushima Plant was the worst since Chernobyl. The second one is used as an additional argument, A4, to support the first proposition, even though the first proposition is accepted by the audience and really requires no additional support. However, once accepted the first proposition provides a premise in a counterargument, C1, that attacks the previously accepted proposition that nuclear power is safe. Hence that proposition is now shown in the text box with a white background, indicating that it is no longer accepted by the audience.

Hence what we have seen is that in this case both arguments A1 and A2 have been successfully attacked by the invention system. It has searched around in the database of propositions accepted by the audience, and found ones that can be used in additional arguments that successfully attacked the two existing arguments. Next we need to examine whether this procedure could be carried even further. Could the invention system find new arguments that would attack the counterargument shown in figure 7?

Such a procedure could be carried out by the invention system as shown by the new arguments collected by the system and visualized in figure 8.

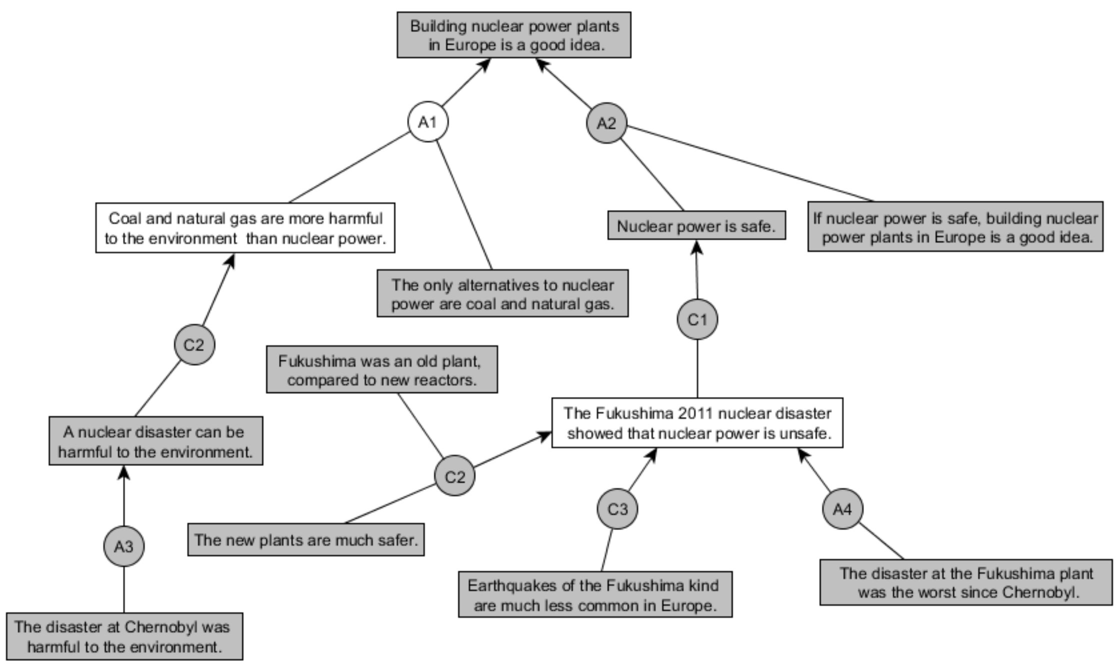

Figure 8: Additional New Arguments Found by the Invention System

These new arguments are shown at the bottom of the argument map. In the previous figure, the key premise that nuclear power is safe was attacked by an argument based on the premise that the Fukushima 2011 nuclear disaster showed that nuclear power is unsafe. Two new counterarguments are posed in figure 8 that attack this key premise. One is a single premised argument based on the proposition that earthquakes of the Fukushima kind are much less common in Europe. The other is a linked argument with two premises. One premise is that Fukushima was an old plant, compared to new reactors. The other premise is the statement that the new plants are much safer. Assuming that the audience accepts both propositions in this linked argument, and that the argument is valid, it poses a persuasive counterargument against the proposition that the Fukushima 2011 nuclear disaster showed that nuclear power is unsafe. What is shown then is that there are two counterarguments against this proposition, and each of the counterarguments has all of its premises accepted by the audience. So here we have two counterarguments pitted against one supporting argument for the claim that the Fukushima 2011 nuclear disaster showed that nuclear power is unsafe. For this reason that proposition is now shown as not accepted by the audience, as indicated by its appearing in a text box with a white background in figure 8. Hence the counterattack against the proposition that nuclear power is safe is now defeated, and this proposition, now once again accepted by the audience, is shown in a darkened box in figure 8.

The outcome for the argumentation shown in figure 8 is that although argument A1 in favor of the ultimate conclusion is still defeated, argument A2 is now persuasive to the audience, because the previous counterattack on it has been refuted. On the basis that one argument for the ultimate conclusion that building nuclear power plants in Europe is a good idea is valid and has two premises accepted by the audience, even though, as things stand, the other arguments supporting that conclusion has been successfully attacked, the final outcome is that the ultimate conclusion should be accepted. One argument supporting it is successful to persuade the audience based on what they accept, and no counterargument attacking it is successful in showing that the audience does not accept the conclusion. The argument invention system could still try to find additional ways to make argument A1 successful, but perhaps there are no premises in the database of propositions accepted by the audience that can be used for this purpose. Even so, one argument has been found that stands up to criticism.

6. Some Recent Computational Argumentation Systems

There are now a number of formal argumentation systems used in artificial intelligence that model argumentation along the lines set out in section 3 (Scheuer et al., 2010) and that therefore could be used to help find arguments. There is only space here to mention three of them.

Prakken’s formal argumentation system ASPIC+ uses deductive forms of reasoning as well as defeasible argumentation schemes (comparable to Aristotelian topics) that only make a conclusion tentatively acceptable if its premises are accepted. In his system, an argument has to be capable of being defended against counterarguments (Prakken, 2010). In ASPIC+ the proponent starts with the argument he wants to prove and when the opponent has his turn, he must provide a counter-argument. Each argument can be defeated by other arguments, which can themselves be defeated by other arguments. Hence in a given case of argumentation there is typically a sequence in which each argument attacks another, and then the attacking argument is attacked by another attacker, and so forth.

In the system of Bart Verheij called DefLog, an argument visualization tool called ArguMed helps a user to construct an argument diagram showing the chain of argumentation with its premises and conclusions (Verheij, 2003, 320). ArguMed is available at no cost on the Internet (http://www.ai.rug.nl/~verheij/aaa/argumed3.htm). The ultimate conclusion, called the issue in ArguMed, appears in a text box at the top of the argument diagram. The arguments supporting or attacking the ultimate conclusion are linked together in sequences leading to the conclusion, as shown in numerous examples in (Verheij, 2005).

The Carneades Argumentation System (CAS) can be used to analyze and evaluate arguments, to visualize them as argument diagrams, and to construct arguments to prove a proposition at issue (Gordon, 2010). The visualization tool is available at no cost at http://carneades.github.com.

CAS uses proof standards to evaluate when an argument is successful to prove a claim. The proof standard is determined not by the audience but by the type of dialogue the arguer is engaged in and the procedural rules appropriate for the type of dialogue. For example in law, in a civil case the standard of preponderance of the evidence is used. In a criminal case the standard of beyond a reasonable doubt is used. CAS was designed to model legal argumentation, but is domain independent, meaning that it can be applied to argumentation in any domain or field. A special feature of CAS is an automated assistant to help a user find arguments (Ballnat and Gordon, 2010).

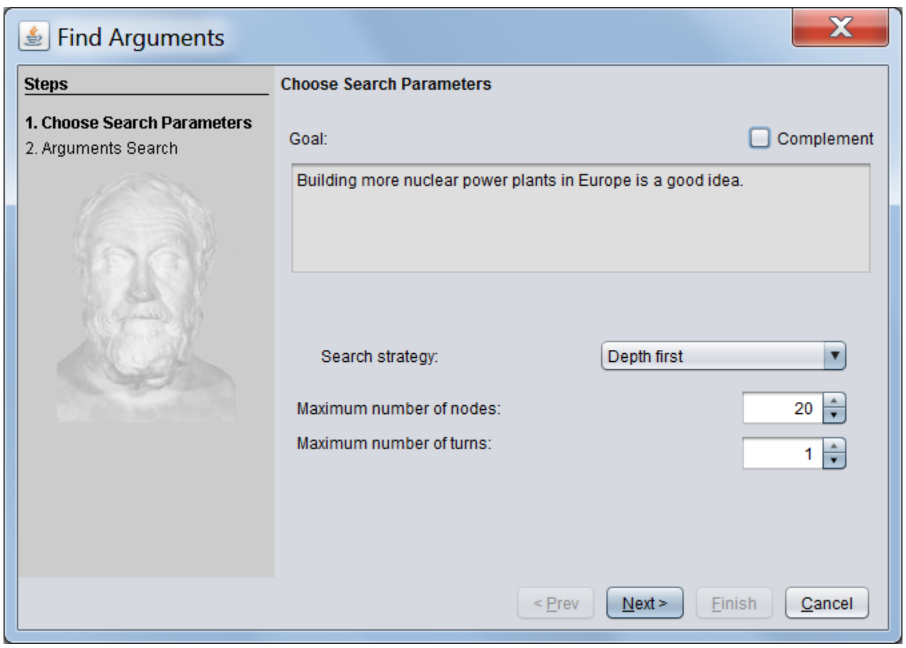

Figure 9: The Find Arguments Assistant in CAS

CAS has an information service that collects new data on the Internet that can be added to its database and used to collect new arguments that are employed to persuade an audience. How the method of finding arguments works in CAS is explained in detail through the use of shorter and longer examples in (Walton and Gordon, 2012).

7. Conclusions

The lessons of this paper can be summarized as a story line of development from ancient logic and rhetoric to the present situation of the art of finding arguments. It was shown in the first section that the role of Aristotelian topics has always been taken to be important for argument invention. It was shown in the second section that topics are part of an Aristotelian framework in which the art of invention selects premises to be used in a chain of argumentation from a database of propositions accepted by the audience the speaker is trying to persuade. The ancient status theory provides a framework in which invention is used to find arguments to persuade an audience. The framework presupposes that there is an issue to be resolved between two parties. In the framework of invention these two parties are the arguer and the audience. The arguer is trying to persuade the audience to accept a particular proposition designated as his ultimate probandum. The issue is that the audience either accepts a proposition that is the opposite of the arguer's ultimate probandum or is at least skeptical about accepting this proposition. To carry out his task, the arguer has two main tools. One is that he has access to a database of propositions that are generally accepted, and are accepted by the particular audience who his argument is designed to persuade. The other is that he can apply argumentation schemes to this set of propositions to build up new arguments that chain forward in such a fashion that he can prove his ultimate probandum from propositions accepted by the audience. Such, in outline, was the framework provided by the ancient art of finding arguments.

As shown by Kienpointner's survey, this framework for finding arguments was discredited in the 17th century by Arnauld. Since the Enlightenment it is generally been taken for granted that the only database that is important for building arguments is the set of propositions objectively proved by scientific methods. Plausible reasoning of the kind based on topics or argumentation schemes was discredited as merely subjective. In the late 20th century however, generally accepted opinions about the art of finding arguments began to change, especially with the advent of the new rhetoric (Perelman and Olbrechts-Tyteca, 1969), a book that advocated using argumentation schemes both for argument evaluation and argument invention, in legal reasoning as well as everyday conversational argumentation. However, at this time, there seemed to be little hope of actually building a working tool that could be used to help an arguer find arguments.

Section 3 showed however that with the advent of knowledge-based systems, such as the expert systems developed in artificial intelligence in the late 20th century, such a framework became available. Artificial intelligence systems provided a framework in which propositions accepted by an audience along with argumentation schemes can be used as a knowledge base to move a chain of argumentation forward towards the ultimate conclusion to be proved by an arguer. The procedure works by continually drawing on the knowledge base to find missing premises and arguments to keep the argumentation chain moving forward towards the ultimate conclusion to be proved. The simple example given in figure 3 provided a general outline showing how this kind of structure of argument invention works in practical terms. The lesson of this demonstration is that there is a method for finding arguments available within structures already widely used in artificial intelligence. It shows that formal argumentation systems of the kind that have been developed in artificial intelligence, such as ASPIC+, DefLog and CAS, can easily be adapted to make them into tools for argument invention. These observations expand the capability of formal argumentation systems. It shows that they can be used to not only analyze and evaluate arguments, but also to construct arguments. In particular, they can be used to find arguments from a database made up of propositions accepted by an audience. What is shown is that logic, the ancient kind of logic called dialectic by Aristotle, can be combined with rhetoric so that the logical device of chaining arguments from a database towards an ultimate probandum becomes a tool that can be used to assist an arguer to persuade an audience that they should accept his claim based on premises that they are committed to.

This new knowledge-based framework for argument invention works best in complex cases where there is a large database of propositions accepted by the audience that can be used as premises. For example, consider a legal case where a lawyer is trying to persuade the audience to accept his ultimate probandum, for example the proposition that the accused party is guilty of committing the crime he was accused of (Hohmann, 1989). In this instance the audience will be a judge or jury, and the database of accepted propositions will be the admissible evidence in the case. During the trial procedure itself, the database will change as new evidence comes in, for example testimony by witnesses. Moreover it will be expected that the database will contain contradictions. For example one witness might testify to a particular proposition whereas another witness may claim the opposite. A more complex example of this sort is given in (Walton and Gordon, 2012), where CAS was applied to an argument about copyright for a software system. However, the examples given in sections 4 and 5 were intentionally made to be as simple as possible, so that a reader can figure out basically how such a system of argument invention will work.

In the example illustrated in figures 4 and 5, some propositions, for example the proposition that anyone can edit Wikipedia entries, are taken to be accepted by the audience based on common knowledge. No attempt was made in this example to actually assemble a database of all the common knowledge about the reliability of Wikipedia. It is assumed that the invention system would draw from a set of propositions. But the reader can easily see through this example how the system would work. Some additional propositions supposedly accepted by the audience are inserted as new premises, and these insertions give the arguer the capability of supporting his argument for his claim that Wikipedia is reliable, and also for refuting the counterargument that claims that Wikipedia is subject to errors. Basically this is how an automated system of argument invention will work in outline, even though in a really challenging case it may be difficult to find the best line of argumentation moving forward from the accepted premises to the designated conclusion. In such cases there will be alternative lines of argumentation moving forwards towards the ultimate claim, and the argument invention system will provide some way of selecting the best way forward.

In section 5, a more elaborate version of Kienpointner's nuclear power example was presented to show a slightly more complex case of argument invention. In this case there was an initial argument in which all the premises were accepted. It is an example of a successful argument used to find arguments to support the claim that building nuclear power plants in Europe is a good idea. There were two arguments, A1 and A2 displayed in the diagram in figure 6, and each of them had two premises that were accepted by the audience. Then as displayed in figure 7, new premises and arguments were drawn from the database of propositions accepted by the audience, and these were used to attack one of the premises in each of the two arguments. In the final phase of the example shown in figure 8, it was shown how the attacking arguments could themselves be attacked in a new round of finding arguments. This procedure illustrates the argumentation technology used by the system ASPIC+, outlined in section 6. In this argumentation procedure the proponent starts with an argument he wants to prove and then the opponent takes his turn to provide a counterargument attacking the proponent's argument. At the next step in the sequence the proponent has his turn to attack the arguments of the opponent. This sequence continues until the one party or the other runs out of arguments.

In general, what is shown in this paper is that we are entering a new era in which technologies for argument invention will be made possible by the new computational argumentation systems currently being built in artificial intelligence. The implications of these developments for reconfiguring the borderlines between the subjects of logic and rhetoric are highly significant. Automated argumentation-based tools for argument invention show potential for being used as argument assistants. Such an assistant can search around in a database for useful arguments to help an arguer move forward in his attempts to persuade his audience of his claim, and then present the arguments to the rhetorical speaker.

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