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ANALOGY RECOGNITION AND COMPREHENSION IN EDITORIALS

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ABSTRACT

Analogical reasoning is an important part of human intelligence. We often employ it as a vehicle for conveying ideas, and we rely upon it whenever we make a decision about a new situation [STER77]. This paper presents a theory of analogy recognition and comprehension, using as a domain letters to the editors of weekly news magazines. Our theory relies on lexical clues and the comparison of conceptual similarities to trigger recognition of the analogies in these letters. Our conceptual representation of an analogy in memory utilizes comparison links to map analogous elements to each other, and to tie together parallel arguments. We demonstrate application of this theory to a prototypical letter. The current status of a program implementing this theory is reviewed, and future research directions are discussed.

1. Introduction

Our research addresses the role of analogy in editorial comprehension, in argumentation, and in question-answer processing, using the domain of editorial letters [AUGU85] [AUGU85a]. The theory presented here is implemented in JULIP, a computer program which accepts as input a conceptual representation of a prototypical editorial letter. JULIP is part of the OpEd project [ALVA85]. The goal of OpEd is to develop a theory about the process of reasoning comprehension in the domain of editorials. The focus of JULIP is on the role of analogy in argumentation. The objective of this task is to recognize the presence of the analogy in the letter to the editor, map analogous elements together, and perform any transformations needed to complete the analogy. Understanding of the analogies presented to JULIP is demonstrated via a question-answer session with the user.

2. Analogical Reasoning in Natural Language Processing -- Some Background

Researchers in linguistics, education, psychology and other academic disciplines have studied the use of analogy and metaphor in depth [LAKO80] [ORTO79] [STER77]. Recent contributions by AI researchers in the area of computational models of analogical reasoning include [CARB83], in which Carbonell extends means-ends analysis to utilize past problem-solving experience in solving new problems. JULIP draws upon Carbonell's work in transferring experience among related problems in solving the current problem. In addition, JULIP relies upon domain specific knowledge in solving problems.

One area of analogical reasoning for which few computational theories exist is the study of analogy from the point of view of its use in editorials, arguments, conversation, debates, narratives, or other aspects of natural language text. Our work falls into this category. Two examples of related work are Winston's work on learning by analogy [WINS82] and Lebowitz' IPP [LEBO80].

In Winston's system [WINS82], a teacher uses precedents and exercises to teach the system rules about relations in a particular domain. While Winston's system is able to perform some analogical reasoning on the narratives, it does not recognize the narratives as being analogous without the assistance of the teacher. Also, the ability to make analogical mappings relies upon the existence of a

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common ancestor in the AKO hierarchy of the situation parts to be mapped [WINS78] [WINS80] [WINS82]. Additional domain knowledge and past experience in making the analogical mappings are not utilized in Winston's system. As a result, the system's performance does not improve over time, and only obviously similar stories can be mapped to one another.

IPP [LEBO80] compared new wire service stories to similar events previously stored in memory. Events were indexed in memory according to their similarities and differences. IPP was successful in finding events similar to the new one and was able to form generalizations allowing it to learn about its domain. However, IPP did not form specific analogical mappings and did not deal with disputes, arguments, or beliefs.

In contrast to the work by Winston and Lebowitz, JULIP deals with the role of analogy in arguments. The objectives of JULIP include being able to have the system recognize the presence of an analogy in the input without it being identified as such by the user. The objectives also include representing the analogy itself, utilizing specific analogical mappings to show how the components of the analogy are related to one another, and being able to reason about the purpose of and basis for the analogy itself, as well as its role in an argument.

3. The Issues in Understanding Editorial Analogies

The following hypothetical letter to an editor illustrates the issues which arise in developing a system which will understanding analogies in editorial letters:

HIGH-TECH-1

> Some people are against computers because computers eliminate people's jobs. However, the automobile industry did the same thing to people in the horse carriage industry. Yet consumer demand for autos was strong enough that eventually more jobs were created in the auto industry than were lost in the horse carriage industry. In the end, the economy benefitted by the introduction of the new technology.

The author of HIGH-TECH-1 is arguing that the introduction of computer technology will eventually improve the economy by increasing the number of positions available in the job market. This point is never explicitly made in the text. Instead, it is argued by analogy to a similar situation resulting from the introduction of the automobile. We can identify three basic issues central to the theory encompassed by JULIP:

1) the ability to understand analogies:
to recognize them, to map together the source or familiar domain and the target or unfamiliar domain, and to transform information available in one domain to fill gaps in the information available about the other domain

2) the ability to understand arguments:
to identify propositions, and to relate propositions in support or attack relationships

3) the ability to understand the role that analogy plays in the structure of arguments

Our approach to addressing these issues incorporates the natural language comprehension component in BORIS [DYER83], the work by Flowers et al. on representation of beliefs and the structure of arguments [FLOW82], and Alvarado's work on the use of argument units to support belief recognition and inferencing about beliefs [ALVA85] [ALVA85a]. Our memory organization and causal reasoning components are based upon Schank's work [SCHA82] [SCHA77], and the implementation of JULIP'S question-answer processing draws upon Lehnert's work in this area [LEHN78].

4. Recognizing Analogies in Editorials

How is the presence of an analogy in an editorial recognized? Unless the existence of the analogy is recognized, the information associated with it is not available, and the reader will have difficulty following the author's argument.

Analogy recognition mechanisms can be activated in either of two ways. First, *analogy recognition mechanisms can be expectation driven*. In this case, the reader anticipates that the author will use an analogy, and actively seeks it out in the text. Second, *analogy recognition mechanisms can be* *data driven*. In this case, the analogy is indicated by the text of the letter, or by the similarity of concepts directly presented in the letter. Both components are necessary for accurate identification of analogies. If recognition were activated only top down, the reader would miss analogies not specifically identified as such in the text. On the other hand, if recognition were only bottom up, the reader would spend a lot of time processing analogies that were never intended.

4.1 Expectation-Driven Analogy Recognition

Understanding an editorial requires that the reader identify the dispute being presented, and the technique being used to support or refute the author's arguments. Analogy is one of these techniques. Consider the following letter:

HIGH-TECH-5

> Would those who complain about computer-related job loss care to do without their cars? Buggy whip makers undoubtedly voiced similar concerns in their heyday. And I wonder how many of those complainers are employed in the auto industry.

A subject shown just the first sentence of this letter keyed in on the complainers, and drew an analogy between the introduction of the automobile industry and the introduction of computer technology. Yet nothing in the text of the first sentence directly relates the two. The subject's familiarity with the arguments in favor of the introduction of new technology enabled him to immediately focus in the comparison of the two events in the author's rhetorical question and caused him to anticipate that the author would argue the point by analogy.

4.2 Data-Driven Analogy Recognition

There are two main data driven indicators of the presence of an analogy: 1) textual clues, and 2) conceptual similarities. JULIP relies upon both of these indicators to identify the presence of an analogy.

The use of textual clues provides the most direct technique for introducing an analogy into an editorial letter. Phrases often used to directly link the source to the target are "the same as", "the same thing", "similar to", and "so it is with". This technique is used in HIGH-TECH-1, for example, when the author writes "the automobile industry *did the same thing* to people in the horse carriage industry".

People can readily detect the presence of an analogy even in the absence of textual clues. Such would be the case if the second sentence of HIGH-TECH-1 read "the automobile industry *caused* people in the horse carriage industry *to lose jobs*". In such cases, people seem to categorize concept in memory as they are encountered in the text. For a computer program to recognize an analogy presented this way, conceptual representations must be categorized as they are built, and linked together in the order in which they are encountered. As new elements are added to each category, similarity measures and other heuristics must be employed to determine whether an analogy is intended.

4.3 Constraining Comparisons: Where Does Mapping Begin and End?

Once a reader realizes that the author might be using analogy to argue a point, she must decide what elements of each domain form the basis for a mapping between the two domains, and what that mapping tells her about the author's point. Mapping of the analogy is driven by the similarities and differences between the domains of the analogy. Aspects of the domains which are similar and related to the point of the analogy support the analogy and are mapped together. Aspects of the domains which stand in contrast to each other and are unrelated to the point of the analogy do not support the analogy and are not mapped together.

5. Analogy in Argumentation

The ability to argue by analogy presumes an ability to argue in general. What framework enables people to argue? Familiarity with basic argument strategies gives people a basis around which to build arguments in support of the points they wish to convey. Alvarado et al. refer to the structure underlying arguments as argument units, and describe techniques for recognizing these units and reasoning about them [ALVA85] [ALVA85a].

5.1 Representing the Analogy in an Editorial Letter

Representing the analogy in an editorial letter requires that the arguments in the editorial be represented, and that the relationship of the arguments to each other in the context of the analogy be maintained in memory. For example, in HIGH-TECH-1, each argument contains two beliefs [AUGU85]. First, in the target domain there is the belief (ARG-1) that the computer industry is bad, because it leads to job loss. Next, there is belief that, by the same line of reasoning, the automobile industry was bad, because it, too, led to job loss (ARG-2). Both of these beliefs are supported by the fact that losing a job is considered to be bad, and, more generally, by the argument rule that

Arg-Rule-1:
X is bad
IF X leads to Y and Y is bad.

These beliefs are represented using the argument structures and rules developed in [FLOW82], [ALVA85] and [ALVA85a]. Comparison links are constructed to map ARG-1 and ARG-2, the computer and auto industries, and the causal relationships justifying the beliefs proposed about these industries.

The author's statement that the automobile industry actually led to an improved economy is viewed as a contradiction to the justification for the belief in ARG-2, and an instantiation of the argument attack strategy that

Arg-Strategy-1
IF Arg-Rule-1 holds and Y is a low-level goal,
THEN attack by showing that Y also achieves a high-level goal.

In HIGH-TECH-1, having jobs in the short term (Y) is seen as being a lower-level goal than increasing the total number of jobs available in the long run. This leads to marking ARG-2 in memory as having been attacked by this new causal relationship. Since ARG-1 is analogous to ARG-2, by the same line of reasoning ARG-1 is marked in the same way. A new belief (ARG-2') is constructed: the automobile industry is good, because it leads to an increased job market. Because of the analogical mapping between ARG-1 and ARG2, and between the industries, a fourth belief (ARG-1') is constructed: the computer industry is good, because it, too, will lead to an increased job market. The analogous components of these two new belief structures are mapped together.

6. Analogy and Question Answer Processing

Demonstrating that an analogy has been completed and understood requires answering the following categories of question:

1) Mapping: Were the key features of the source and target domains linked together?

2) Transforms: Were important features missing from one domain supplied by transforming information available from the other domain?

3) Basis: What was the purpose of the analogy? Why was the comparison made?

The heuristics needed to categorize and perform a memory search for questions in each of these categories are based upon extensions to the theory developed in Lehnert's QUALM [LEHN78]. The heuristics implemented in JULIP extend beyond Lehnert's for two reasons. First, the concepts in an editorial revolve around arguments, rather than around script instantiations. JULIP's memory search heuristics take this into account. Secondly, JULIP's representation scheme utilizes memory links that are not considered by Lehnert in QUALM.

Mapping questions demonstrate whether those similarities in the source and target domains which are related to the point of the analogy have been linked to one another. In JULIP, mapping is noted in a comparison or COMPARED-TO link, a link not considered by Lehnert. The memory search heuristics for mapping questions require retrieving the value found in the COMPARED-TO slot of the named concept.

Understanding an analogy often requires inferring information not explicitly mentioned in the text regarding one domain by transforming information available from the other domain. Transform questions demonstrate that this inferencing has taken place. For example, in HIGH-TECH-1 the question *What did the auto industry do to people in the horse carriage industry?* should elicit the reply *PEOPLE IN THE HORSE CARRIAGE INDUSTRY LOST JOBS.* The relationship between the auto and horse carriage industries is never explicitly mentioned in the text of HIGH-TECH-1. It is inferred from the previously understood relationship between the computer industry and job loss of people on assembly lines. This is a Causal Consequent question [LEHN78], in which the the question concept is the antecedent of a causal structure. The heuristic used in this case is to retrieve the consequent of that causal structure as the answer to the question. The question category of other transform questions depends upon the type of inference to be demonstrated.

In arguing by analogy, an author states a belief in one domain, then proceeds to argue the point in a second domain. She might or might not repeat the argument in the original domain. When the author does not return to the original domain, the reader has the job of completing the analogy by creating a parallel argument in the original domain. To demonstrate successful comprehension of the author's actual point, a reader should be able to answer questions regarding the completion of the analogy. Such a question in HIGH-TECH-1 is *What will happen as computers eliminate jobs?* The reply *AN EVEN GREATER NUMBER OF NEW JOBS WILL BE CREATED.* would reflect the reader's successful comprehension of the analogy. This question is a request for a co-temporal event, a question category not considered in Lehnert's work. JULIP's memory search heuristics for co-temporal events cause it to search for another concept sharing a slot with the named concept.

Basis questions are similar to Lehnert's Goal Orientation questions, because they ask "For what purpose..." However, they differ in that they have to do with the author's goal of communicating with the reader, rather than having something to do with the events, plans, and goals associated with the components of the analogy themselves. The basic heuristic for retrieving the answer to a basis question regarding two beliefs is to generalize the justification for the beliefs. In the event that contradictory beliefs have been stated, as in the case of HIGH-TECH-1 in which the computer and auto industries are alternately considered to be good and bad, an additional heuristic comes into play: *retrieve the justification from arguments that still hold or were not attacked.*

7. Current Status

JULIP currently works on a hand-coded representation of HIGH-TECH-1, developed by following the parsing strategies described in this paper. This representation is built in memory using ARF [EDWA84]. JULIP accepts queries in English, searches a completed argument graph in memory, and returns the conceptual representation of the results of the query. Our current objective is to demonstrate understanding of editorial analogies given to the program in English through a natural language question-answer session with the user. JULIP is able to answer questions about HIGH-TECH-1 in each of the four categories listed above [AUGU85].

The most immediate plan for JULIP is to develop the parsing and generation components of JULIP that will enable it to handle verbatim input. Our approach will be to translate the theory presented here into the demons and lexical entries needed to support analogy recognition and comprehension in DYPAR, the parsing component of BORIS [DYER83]. The theory will continue to develop as additional editorial letters containing analogies and human protocols for understanding them are analyzed.

8. Problems for the Future

Many issues still need to be addressed in JULIP. Among these issues are question answer processing on the role of analogy in arguments, learning from analogies in editorial letters, and generating analogies.

The question categories currently supported in JULIP relate mainly to the completion of the analogy presented to the system. Additional question-answering heuristics need to be developed to deal with the role of an analogy in an argument. This would enable JULIP to answer, for example, the following questions relating to HIGH-TECH-1: Why was the auto industry mentioned in the argument? Why doesn't the letter's author agree with the argument that the computer industry is bad?

Work on JULIP has concentrated on representation of the analogy in the letter, leaving unanswered the following questions which deal with the issue of learning by analogies from the editorial domain: What conclusion is drawn from the analogy and learned, or retained in LTM? Why is this learned? How does JULIP's prior knowledge state affect the conclusion? How does question-answer processing affect the conclusion? How does the conclusion affect future comprehension?

Future work will explore the possibility of reversing the process of analogy comprehension in order to fulfill a long range goal of this research: to build a system which can generate arguments by analogy on its own.

9. Conclusions

We have shown how the analogy recognition mechanisms in the domain of editorial letters can be both expectation driven and data driven. Comparison links provide a means for representing the mapping of the source and targets domains of an editorial analogy in memory. Both domain knowledge and an understanding of the structure of arguments in general enable JULIP to transform an argument in in one domain of the analogy to the other domain.

JULIP provides a foundation for adding the ability to support analogy recognition and comprehension in the integrated natural language parser OpEd [ALVA85].

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