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Graeme Hirst

Anaphora in Natural Language Understanding: A Survey

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In loving memory of my Father

PREFACE

I was a victim of a series of accidents.
– Kurt Vonnegut Jr[1]

This report was started in the boreal summer of 1976, making its first appearance as Hirst (1976b), and was completed almost three years later, after a number of lapses and relapses. Like a chinchilla one is trying to photograph, the field I was trying to describe would not sit still. Therefore, while I have tried to incorporate all the changes that occurred in those years, there may be some blurring at the edges.

I have tried to make this survey comprehensible both to the computer scientist who has no grounding in linguistics, and to the linguist who knows nothing of computers. However, it has been necessary to presume some information, since digressions to explain transformational grammar or Fillmore's case theory, for example, were clearly impractical. (Readers not familiar with these may wish to read an introductory text on transformational grammars such as Jacobsen (1977), Akmajian and Heny (1975) or Grinder and Elgin (1973), and Fillmore's (1968) introduction to cases. The reader not familiar with artificial intelligence will find Winston (1977), Boden (1977) or Bundy (1979) useful introductions.)

It is to be noted, that when any part of this paper appears dull, there is a design in it.
– Richard Steele[2]

How to read this report

This is a long report, but few people will need to read it all. The Chapter outlines below will help you find the sections of greatest interest to you.

Chapter 1 introduces and motivates work on natural language understanding and in particular anaphora. If you are already motivated, skip to Chapter 2.

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[1]From: *The sirens of Titan*. London: Coronet, 1967, page 161.

[2]In: *The tatler*, number 38, Thursday 7 July 1709. Reprinted in: *The tatler, with notes and illustrations*. Edinburgh: Robert Martin, 1845, volume 1, page 236.

Chapter 2 defines anaphora formally, and motivates the idea of "consciousness" as a repository for antecedents. Section 2.3 is an exposition of the various types of anaphora. I suggest that readers familiar with anaphora nevertheless at least skim this section, as I have included a number of unusual examples and counterexamples which are often ignored but which should be considered by anyone claiming to have a complete anaphor-handling system or theory.

Chapter 3 reviews traditional approaches to anaphora resolution, and shows why they are inadequate. Section 3.1 discusses the work of Bobrow, Winograd, Woods and his associates, Schank and his students, Taylor, Hobbs and Wilks. Then in section 3.2 I abstract and evaluate the approaches these people took.

In Chapter 4, I show the importance of discourse theme and anaphoric focus in reference resolution.

In Chapter 5 I review five current discourse-oriented approaches to anaphora – those of Kantor, Grosz, Sidner, Webber, and the discourse cohesion approach of Lockman and others. Approaches to non-NP anaphora are also outlined here.

Chapter 6 describes the role of anaphor-specific information in resolution, and integrates theories of causal valence into a more general framework.

Chapter 7 discusses some issues raised in earlier chapters, such as psycholinguistic testing, and also the problems of anaphora in language generation. The report concludes with a review of outstanding problems.

Copious bibliographic references will keep you busy in the library for hours, and an index of names will help you find out where in this work your favorite work is discussed. A subject index is also provided.

Notation

In the sample texts in this report, I use underlining to indicate the anaphor(s) of interest, the symbol ϕ to explicitly mark the place where an ellipsis occurred, and small capitals to indicate words that are stressed when the sentence is spoken. Superscript numbers in parentheses are sometimes used to explicitly label different occurrences of the same word in a text. Variant readings of a text are enclosed in braces, with the variations separated by a vertical bar. A sentence which is grammatical but unacceptable in the given context is denoted by "#". As usual, "*" and "?" denote text which is ill-formed and of questionable well-formedness, respectively.

In the main body of the report, I use small capitals for emphasis or to indicate that a new term is being defined. Italics have their usual metalinguistic role in referring to words and phrases. *NP* and *VP* stand for *noun phrase* and *verb phrase*.

By *I*, I mean myself, Graeme Hirst, the writer of this document, and by *we*, I mean you, the reader, and me together. So, for example, when I say *I think*..., I am expressing a personal opinion; whereas when I say *we see*..., I am pointing out something about which the reader and I undoubtedly agree – and we don't, the fault is probably in the reader.

PREFACE TO THE SPRINGER EDITION

I originally wrote this report as a thesis for the Master of Science degree in the Department of Engineering Physics, Australian National University. The thesis was also published as technical report 79-2 (May 1979) by the Department of Computer Science, University of British Columbia,

In the year or so preceding the first publication of the report, the study of anaphora in natural language understanding was a very current topic, with the publication of several important doctoral theses (which are reviewed in Chapter 5). I had originally believed that the field was changing so fast that the survey would be substantially out of date within a year. This has not proved to be the case; rather, work in the area has slowed, as researchers pause to evaluate and reconsider the approaches taken. I now think that this report has a longer-than-anticipated life expectancy, and that it will continue to be helpful to those constructing natural language understanding systems.

The present edition was typeset with a text-formatting system that is unfortunately typical of many found in computer science departments, in that it was designed by people who know a lot about computers but not very much about typography or book design. I hope therefore that you will forgive the occasional footnote that runs onto a new page when it shouldn't have, some ludicrous hyphenation, the funny shape of certain letters, and the awkward widows that turn up in a few places. The page numbers in the indexes should be regarded as approximate only, especially where the reference is in a footnote carried over to the next page.

Providence, 1 May 1981

ACKNOWLEDGEMENTS

Who made me the genius I am today –
The mathematician that others all quote?
Who's the professor that made me that way?
The greatest that ever got chalk on his coat!
One man deserves the credit, one man deserves the blame,
And Nicolai Ivanovich Lobachevsky is his name.
– *Tom Lehrer*[1]

I wrote this survey while a graduate student at the Department of Computer Science, University of British Columbia; my supervisor was Richard Rosenberg. Parts were also written at the Department of Engineering Physics, Research School of Physical Sciences, Australian National University (ANU), under the joint supervision of Stephen Kaneff and Iain Macleod.

Without the encouragement of Robin Stanton, this work would never have been started.

Discussions with and/or comments and criticism from the following people improved the quality of this report: Roger Browse, Wallace Chafe, Jim Davidson, Barbara Grosz, M A K Halliday, Alan Mackworth, Bonnie Nash-Webber (in 1977), Doug Teeple and Bonnie Webber (in 1978). Nevertheless, the mistakes are my responsibility (except in any instance where, in presenting the work of another, I have been misled through the original author's inability to communicate coherently, in which case the original author must take the blame).

Financial support came from the Australian Department of Education as a Commonwealth Postgraduate Research (CPR) Award, from ANU as a CPR Award supplement, and as a special grant from the ANU Department of Engineering Physics.

Many spelling errors and stylistic grossosities have been eliminated through the detective work of Mark Scott Johnson, Nadia Talent, Iain Macleod and M W Peacock.

Finally, I want to especially acknowledge the help of two people: Richard Rosenberg, who first interested me in this work and encouraged me to complete it, and Nadia Talent, without whom it would all have turned out quite differently.

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[1]From: Nicolai Ivanovich Lobachevsky. On: Lehrer, Tom. *Songs by Tom Lehrer.* LP recording, Reprise RS6216.