ARTIFICIAL INTELLIGENCE: Applications to Logical Reasoning and Historical Research

RICHARD ENNALS

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Preface and acknowledgements

This book has been many years in the making. It addresses problems of understanding in history and the humanities that have been of academic concern for centuries within the confines of a number of different disciplines. Exploring such problems has required the author to be something of a hybrid, and has led him to explore the potential of different media and technologies.

The role of the history teacher has often been appropriate, for teachers have to make themselves expert in diverse fields at different levels and with different modes of expression to their different audiences of individuals and groups. Those who are concerned with the construction of expert systems have a long way to go before they can match the knowledge, skills, and flexibility required of a good history teacher today.

I focus in this book on the role of logic and of logic programming, for it seems to me that here at last we have a generally acceptable notation in which we can describe what we mean, where our description taken as a program can serve to demonstrate what we mean to others.

There has been an Anglo-Saxon tradition of dissociating logic from its area of application, which can be contrasted with the French and continental tradition of seeing logic in terms of articulating domains of discourse. As this book sets out to show, logic programming has roots in both of these traditions, and is increasingly providing a medium through which they can communicate.

Another link between the two traditions can be found in the concern of historians and 'human scientists', or students of 'les sciences de l'homme', to make sense of the world around them, and to make intelligent use of available evidence. I have found the closest links in approach between French social historians and British (and Australian) history teachers in the 'New history' school. This is no coincidence, and in this case many of the links can be established through Cambridge, where the French influences have been strong and the effects on British classroom teaching increasing over the last fifteen years.

Much has changed in the development of the new technology of computer science. A new 'fifth generation' of computers is being developed, with which the author is closely associated. Computer scientists, however, are suddenly realizing that, with all their new computing power, they do not have a theory of knowledge that will allow them sensibly to exploit this power. I believe that there is such a theory of knowledge but that computer scientists do not have it. Scientists have been so concerned with how things work, or with constructing intricate working machines that, I would argue, they have lost sight of how things are, and how we can make sense of our world. The declarative use of logic enables us to take insights of our contemporaries and of our predecessors, and to explore them with new power, interrogating the accounts and extracting explanations. There is a vast literature of scholarship and a history of achievement of endeavour. Computer scientists do not read, and few have studied history.

This book cannot claim to solve all the old problems. What it can offer is suggestions based on research and classroom experience, and a trail of references to the ideas from which further advances should come.

The computer technology used in the work described is cheap and widely available. It is interesting that a language, micro-PROLOG, first developed for use with children on the project 'Logic as a computer language' on which the author has worked since 1980, is now in use around the world on computers of all sizes and manufacture. Before teaching the computer scientists we have first had to learn from the children, and, it should be emphasized, from teachers of history, who have taken the lead in so many research projects in Britain and overseas.

This book does not provide a tutorial introduction to logic programming as such. The author has written one such introduction (Ennals 1984a), contributed to another more advanced introduction (Clark & McCabe 1984), and provided short introductions in many other published works. The focus of attention here are the problems arising in history teaching and artificial intelligence, though many of the example programs have a tutorial function in introducing aspects of logic programming and PROLOG. No previous knowledge of PROLOG is required.

My first paper in this field, 'Shakespeare as a historian', was written in 1967. To acknowledge all of those who have helped and influenced me since then would be impossible, but I should mention in particular, in some kind of chronological order: Patrick Richardson, Frank Miles, Mike Smith, Leonard James, Jim Hopkins, Bernard Williams, Roger Scruton, John Dunn, Hugh Anderson, Christopher Morris, Alan MacFarlane, Don Thompson, Peter Lee, Stephen Frank, John Waddleton, Peter Vance, Martin Frampton, Bob Kowalski, Alan Robinson, Keith Clark, Frank McCabe, Diane Reeve, Marek Sergot, Peter Hammond, Derek Brough, Jonathan Briggs, Jon Nichol, and Mike Horwood.

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Material in some of the chapters has appeared in some of my previous publications, and this is indicated in the chapters concerned. I am grateful to the Journal editors and to the publishers of the previous versions for their permission.

My real debt is to my family, Bobbie, Robert, and Christopher, who have supported me throughout.

Hampton
August, 1984

1

The use of the computer in the study and teaching of history: possibilities and priorities for the future

1.1 INTRODUCTION

The computer does not have a long history. It has only recently started to make a serious contribution to the study and teaching of history, and should be regarded as a new apprentice in our ancient trade. Apprentices depend for their development into maturity on the advice, wisdom, and practial experience of their more senior colleagues, and traditionally only expect to be described as competent after a period of years. If we want the computer to be useful to us in the study and teaching of history we will have to be prepared to tell it what it is that we do. Computers can follow the guidance of experts who have been prepared to describe the nature of their expertise. The computer itself is not the problem. Its use should be a consequence of the view that we take of our subject and the role that we assign to the computer as a powerful tool.

The above argument does not apply only to practitioners in the study and teaching of history. Historians are, however, at a considerable potential advantage relative to other professions, and have a great deal to contribute not just to the use of computers in their own discipline, but to the future of the intelligent use of computers in general.

In recent years our approach to the teaching of history has been increasingly affected by our approach to the study of history. Behind the 'New History' lies the idea that we should introduce students to history by involving them in the activity of being an historian. A history lesson will itself constitute a simulation, from the point of view of method. The development of this approach and the appropriate teaching materials has involved considerable reflection on the nature of history as a form of knowledge and its particular subject matter, concepts, patterns of reasoning, and modes of confirming conclusions.

Though the computer itself is of recent vintage, it should be seen in the

context of a concern for problems of knowledge and reasoning that dates from the time of Socrates. Given the large amount of information to be dealt with, and the complex reasoning involved in understanding a variety of human problems, philosophers and logicians for centuries have longed to have access to machines that could automate reasoning and the processing of large bodies of information. The first forty years of the existence of computers were dominated by the demands of the machine: to be addressed in a special language that it understood, to be presented with a specific sequence of operations to be performed, and preferably to be asked to do things that involve numerical operations. Unsurprisingly, historians showed relatively little interest in a machine that involved them in departing significantly from their view of their subject, emphasizing quantitative rather than qualitative elements. The computer systems that are now being built can return us to the older tradition of a concern for problems of knowledge. If they are to work they have need of the insights of the historian, expressed clearly in ordinary language. This field in the United Kingdom has been given the name 'Intelligent Knowledge-Based Systems'. The computing world is short of experts in the intelligent handling of knowledge, and lacks much of the necessary underlying theory. Some historians have started collaborative research and teaching activities, and we can begin to identify possibilities and choose priorities for the future. It is important that we express the possibilities and priorities in terms of history rather than of computing at this stage. Computers and computing are undergoing revolutionary changes at present: the nature of history remains constant though the tools available for its pursuit may change.

For purposes of analysis I will identify three particular important areas of development:

Intelligent information retrieval.
Modelling and simulation.
Explanation and advice.

As will emerge, these areas are far from mutually exclusive. The Historical Association pamphlet *Computers in secondary school history teaching* discussed work in the first two areas, largely using examples from work with minicomputers. Computer technology is now much cheaper, more powerful, and more widely available, as well as being better able to deliver on some of the needs of the historian. There is increasing evidence to support Joseph Hunt's hope that "the great source of the computer in the classroom will be to involve the pupil, far more than hitherto, in active enquiry".

1.2 INTELLIGENT INFORMATION RETRIEVAL

Historians need to obtain and make sense of information, regarded as evidence in the context of a particular problem under examination. Collingwood placed great emphasis on the activity of asking questions, which he described as "the dominant factor in history, as it is in all scientific work". The historian reads his primary and secondary sources "with a question in his mind, having taken the initiative by deciding for himself what he wants to find out from them". Whereas Beverley Labbett has written of "squeezing" his evidence, Collingwood writes

of "putting it to the torture, twisting a passage ostensibly about something quite different into an answer to the question he has decided to ask". The historian needs to be able to ask questions as and when he wants to, and not in a restricted manner laid down by someone else: "It is not enough to cover the ground by having a catalogue of all the questions that have to be asked, and asking every one of them sooner or later: they must be asked in the right order". Asking questions is not enough; one needs to be able to develop and test one's own hypotheses relative to the available evidence. This testing is itself carried out through questionning. "Every time the historian asks a question, he asks it because he thinks he can answer it; that is to say, he has already in his mind a preliminary and tentative idea of the evidence he will be able to use." At the end of the process of enquiry, Collingwood says, the historian hopes to place himself in a position where he can say "the facts which I am now observing are the facts from which I can infer the solution of my problem".

Compared with the sophistication that we require of a computer system to make it a useful extension of the research capacity of the historian or the teaching facilities in a history classroom, standard information retrieval packages available for school microcomputers have serious limitations. Current research in the field of computer science and artificial intelligence offers possibilities of considerable improvements.

(a) Query Systems

It is clearly unsatisfactory to limit the kind of question that can be asked, or to offer only a prespecified range. We need systems that allow the user to describe the information that he wants. Ideally he should be able to do this in English or another natural language. Such systems are being developed, where the computer program has a knowledge of the vocabularly of the particular subject area, and can translate the phrasing of the question into the terms in which the information is expressed in the database. A further step would be to allow spoken questions, recognized and understood by the computer system. Real natural language understanding is extremely complex, and will require larger computers than are currently available in schools.

(b) Databases and knowledge representation

The historian's potential need for the assistance of the computer is greater when he is dealing with a large volume of complex information of variable format. Joseph Hunt quoted the *Times Literary Supplement:* "The computer's demand for homogeneous material seems to have continually encountered the historian's sensitivity to the complex realities involved". There are notable cases, such as the work in Cambridge on the records of Earls Colne, where diverse records have been amalgamated for intelligent use, on large mainframe computers. Typically at school level, where an information retrieval package permits the addition of data chosen by the user, it has to conform to a particular form, and it is not usually possible to add generalization, rules, or related information to enrich the 'knowledge base' under examination. At the research level considerable work has been done on knowledge representation and acquisition, and sophisti-

cated systems are becoming available that allow the user to develop his own complex database without technical expertise. There is of course then a burden on the historian to describe his information clearly and correctly.

There is considerable potential in the linking of different computers through intelligent networks. We could envisage, for instance, having a microcomputer in the classroom with a sophisticated query system linked to databases held on large mainframe computers in the same institution or at a distance. In certain cases we might link a microcomputer to a teletext system such as PRESTEL, or send a specific query to a library or museum by electronic mail. In each case the key component of the intelligent information system is the user, with his choice of question and information.

1.3 MODELLING AND SIMULATION

A number of historical computer simulations have been available for some years, but they tend to lack sophistication both in computing and, more importantly, in historical terms. Few historical programs have taken advantage of the range of graphics and sound facilities available on school and personal microcomputers: many have simply been translated from earlier minicomputer versions.

In historical terms I would be more critical. All too often a historical computer simulation could be carried out with pen and paper: there is a pre-set linear sequence of decisions to be made and a 'correct' answer to each question. 'Incorrect' responses receive little remedial attention, and the student does not have the opportunity to affect the learning experience. It tends to be impossible for the teacher to amend the program for his own purposes or to suit the needs of a particular class. The computer will provide complex information, in trading and business games in particular, but will not explain where it comes from. There will be an underlying model, formula, or program but this is not open to scrutiny or amendment.

A number of improvements can be made, and are being made, with improved understanding of the use of computer technology. The popular vogue for 'adventure games' can be turned to history teaching purposes, with an historical 'micro-world' created within which the individual can explore, making decisions that have clear consequences for the subsequent stages of the game. The sophistication of graphics and sound enhances the appeal of the material, but the historical content is important, and one needs to address the issue of classroom use: how many computers can we assume are to be available for such individual use? With greater memory facitilies becoming available we can add further sophistication, more alternative decisions (allowing 'branching' and not merely linear progress), and greater richness of information and description.

What, however, are we trying to simulate? The conventional simulation concerns the individual decision-maker, such as Drake or Lenin. We can also explore the relationships and decisions of groups of historical agents, each student playing a different role, supported by general and individual briefing materials relating to a particular situation. In order to take a sensible decision 'in character', the students have the aid of a database, available for questionning