Computer Applications in the Humanities

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Summary. The earliest and still most prevalent use of computers in the humanities is the compilation of concordances, rationalized vocabulary lists for literary works. The residue of these efforts has created the potential for extensive databases of natural-language text for a wide range of studies and for instruction. As yet, however, computer-aided instruction has focused on mechanical skills, like spelling and grammar. With rapid advances in storage (like videodisks) and in communications between computers, humanists are finding a challengingly altered environment in which to study and teach.

In September 1964 IBM sponsored a conference at its then-new research facility near Yorktown Heights, New York, to formally recognize that computer technology has a role to play in the humanities. Most of the conferees were using computers to compile concordances, which are alphabetical indices used in literary research, but the "giant brain" (as it was then often called) was also being used in other types of research, such as content analysis and pattern matching. Almost as interesting as the types of work represented at the Yorktown Heights meeting are those omitted from the program, chiefly statistical analyses of language and machine translations, the latter having just been dealt a serious blow by a National Science Foundation report asserting their impossibility (*1*). But, to a large extent, the applications revealed then characterize natural-language research with computers over the ensuing two decades (*2*).

Concordances and Dictionaries

Computer generation of concordances represents an enormous technological advance in producing a type of research tool that had been laboriously manufactured by hand since the early Renaissance (*3*). Its rationale was that, by alphabetizing the vocabulary of a work, one could reveal aspects not visible in its normal linear organization. The initial motive for such restructuring had been the search in the Renaissance for essential truths shared by the four Gospels. In the 19th century the same motive inspired industrious savants to compile concordances to writers like Shakespeare, Wordsworth, and Browning (*4*).

This link between an analytic method and spirituality was evident at Yorktown Heights: one conferee was Father Roberto Busa, an Italian who by then had completed about half of his monumental *Index* to St. Thomas Aquinas (*5*). The first major concordance to be generated in the United States with the help of a computer was based on the works of the Victorian poet Matthew Arnold (*6*).

Father Busa and his contemporaries saw as their goal the conventional printed book. So fixed was this orientation that the input, usually hundreds of pounds of laboriously punched cards, was customarily discarded. Sometimes a tape record was saved, but its status was the equivalent of rough notes for a book or sketches for a painting—artifacts representing the steps of a process but not useful products in their own right. Another noteworthy aspect of this early work was utilization of the computer's counting capacity to perform tasks that would never before have been attempted. Thus, readers of these concordances were informed of the most and least frequent words, what percentage each word constituted of the total, the total number of common words, and so forth. It became necessary to omit certain words to keep the books from breaking the shelves and the budgets of libraries, their chief purchasers. Inevitably, disputes arose over which words were dispensable.

The hundreds of concordances that have appeared since the early 1960's have clearly benefited from the rapid evolution of computer technologies. Photocomposition has rescued us from the imperfectly reproduced, all-capital output of line printers. Microfiche directly generated by computers has made it economically feasible to create concordances for authors whose popularity is too limited to support the cost of printing books.

More significant than these physical improvements is the variety of experiments and interpretations permitted by the computer. Since the base text is input only once and the alphabetizing and selection of contexts are generally performed by the program, the compiler of a concordance has more time to spend on establishing the reliability of the text and even to incorporate several versions, either because there is no simple authoritative one or because an earlier version contains material of importance. The editions of Shakespeare's plays published in his lifetime, for example, differ substantially from the "official" editions published after his death. At least one critic and compiler of concordances has suggested that we may be able to dispense with the concept of a canonical text and deal simultaneously with successive stages of a work (*7*).

Closely related to the production of concordances is the production of dictionaries. The essential differences between the two tools are the extension of the corpus to include an entire language and the replacement of contexts with synthetic definitions. From the 1960's, when Urdang (*8*) imposed the relatively crude technology of that era on the *Random House Dictionary*, to the recent announcement that the venerable *Oxford English Dictionary* will, through grants from IBM and the British government, be redone in a machine-readable format, computers have increasingly taken over the many tasks of dictionary-making. Again, the result has been proliferation. Dictionaries now exist or are in preparation for Old English, Middle English, Old Scots, Old Spanish, Dutch, Italian, and selected non-European languages like Nahuatl (spoken by the descendants of the Aztecs) and Tibetan. A widely publicized dictionary is the *Trésor de la Langue Française*, for the production of which the De Gaulle government built a relatively large building at the University

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of Nancy. Approximately 1600 complete works, intended to represent the spectrum of French writing since 1789, were first analyzed into concordances. These supplied a corps of lexicographers with the raw data for constructing a historical reference work to match the *Oxford English Dictionary*.

To support these activities, research and development centers have been established on many university campuses. Sometimes a center concentrates on more specialized works, such as the analyses of religious documents overseen by Paul Tombeur at the University of Louvain-la-Neuve, the concordances to Ibsen and other Norwegian writers being developed at the University of Bergen under Jostein Hauge, and the concordance to Kant being produced at the University of Bonn under Winfried Lenders. Sometimes no formal center exists, but a dynamic professor acts as one, as Todd K. Bender has done at the University of Wisconsin. At the University of Liège, a laboratory was established by Louis Delatte to conduct statistical analyses of ancient languages. At the University of California, Irvine, Theodore F. Bruner has organized the *Thesaurus Linguae Graecae*, an encoding of all surviving Greek texts from Homer through A.D. 200 and a selection from the ensuing four centuries.

Such centers are serving to create and safeguard machine-readable texts for continuing study, concentrate the expertise of scholars to intensify the analytic thinking required by a potentially radical type of criticism, and train students to master and disseminate the techniques and concepts associated with the new technology. The centers are related to (and occasionally form a part of) new departments of computational linguistics. Among the best known are those at the University of Gothenburg established by Sture Allén and at the University of Pisa by Antonio Zampolli. Doing similar work are institutes at the universities of Besançon, Nice, Strasbourg, Oslo, Leeds, Cambridge, and Texas. Sometimes these are officially dedicated to a specific goal, like machine translation, but all are contributing to our understanding of language and its special uses.

Machine-Readable Text

One result of all this activity is a substantial quantity of machine-readable text. Once it was established that a concordance or dictionary was not the only useful product to be derived from encoding natural-language materials, project directors began to guard their input data in the belief that it would perhaps be of even greater importance for future analyses. The validity of that conviction is being challenged by the Kurzweil Data Entry Machine, which is reputed to be able to "learn" any type font and to translate printed pages into computer tape or disks. If its capabilities are accurately described by its manufacturer (reports from humanists are scarce and conflicting), the creation of machine-readable texts should become almost trivial and hoarding unnecessary. But until the machines are more widely distributed and accessible (they are known to be installed for humanistic use only at Brigham Young University, Dartmouth College, and Oxford University), machine-readable versions of major texts will be of value to scholars.

At Rutgers University, Marianne Gaunt has been compiling an inventory of machine-readable humanities texts designed to capture, with the completeness expected by librarians, details relating to thousands of titles. When the *Trésor de la Langue Française*, *Thesaurus Linguae Graecae*, and hundreds of lesser collections were being made, most attention was directed toward the end product—a concordance, dictionary, or similar work. To go back now and enter all the bibliographic minutiae—essential as they may be to future users—will require thousands of hours and proportionate funds. A completed inventory may encourage future encoders to include the necessary details from the start. The planned dissemination of this information over the computer network of the Research Libraries Group may influence the field of computer-aided literary analysis.

Computing in the humanities, then, faces a substantial period of "catching up." The uncoordinated creation of texts must be replaced by the systematic development of a machine-readable library so that future users know the quality and format of the texts they select. At Oxford University Computing Services, Susan Hockey and Lou Burnard have provided sanctuary for all machine-readable texts offered to them and have mailed tapes of their Oxford Concordance Program to users all over the world. While this attempt to produce a universal text analyzer is slowly achieving the status of a global standard, many other programs remain undistributed and unpublicized. An effort to collect and publish information on all text-processing programs is being initiated at Columbia University by Paula Kaufman.

Computer Networks and Videodisks

Two recent developments have the potential to contribute as much to innovation in humanities research as computers themselves: computer networks and videodisks. Bitnet, a major network not affiliated with any government, has achieved transcontinental and European links and is reaching into the southern United States and Canada. Its remarkably simple principle, established by Ira Fuchs of the City University of New York, is that any institution should be able to afford a telephone link to its nearest neighbor. Universities linked into a network can easily transmit large files, both texts and programs, to any researcher who needs them. The enhanced accessibility of machine-readable texts and of programs to process them should encourage scholars to adopt some of these methods in their historical-critical studies and to incorporate them into seminars for the benefit of students (*9*).

The exact nature of the new methodology is being determined by efforts to establish the authorship of disputed works, to date publications like Shakespeare's plays, to identify major themes through vocabulary, and to characterize style in more precise terms than have been available. Being used for this activity are the statistical packages developed for the social sciences, the lexical databases already mentioned, and on-line analytical tools to identify verbal patterns in literary texts. As it is being used now, the computer is—for better or worse—introducing into literary studies a degree of precision never before attainable.

The videodisk can augment machine-readable text by allowing inclusion of illustrations (such as maps or medieval illuminations) that are an integral part of a work. It can store auditory as well as visual information at high densities, can show action as well as still frames, and can be programmed for a degree of responsiveness that has not yet been demonstrated in systems designed for the microcomputer alone. Although the cost of master disks is still high, the very low cost of duplicating them is an attraction to those who hope to see a democratization of research resources resulting from the application of one or both of these technologies (*10*).

Applications in Higher Education

Microcomputers are by now omnipresent at modern colleges and universities. This phenomenon has been fueled

by several interrelated forces: (i) the substantial knowledge about computers already possessed by matriculating freshmen, who seek universities that offer them computer access and training; (ii) pressures from computer manufacturers to install their brands on as many campuses as possible; (iii) the need to project an "up-to-date" image in the competitive and shrinking student market; and (iv) the more technically minded and job-oriented nature of today's young people.

At institutes of technology like Carnegie-Mellon, Drexel, and Clarkson, humanists are being given microcomputers and asked to find uses for them. Some are also being pressured to develop software, particularly instructional materials. Indeed, humanist faculty members everywhere are being encouraged to participate in the creation of the "totally computerized campus."

Without adequate training in computer applications, however, many humanists have either adopted software ideas from business or used the microcomputer as a "page-turner." Thus we see the repetitive generation of "spelling checkers" that can identify a certain class of errors but cannot discriminate "loose" for "lose" or "lead" from "led." Students who use these programs may be less likely to consult dictionaries for spelling, meaning, or usage, and the gulf is likely to widen between those who recognize the importance of standardized spelling and those who believe that only English teachers are concerned about such details.

Other temptations to think numerically are equally seductive. The mean number of words per sentence, for example, can be translated into a "readability score," from which it is an easy step to assign pejorative values to complex writing. Complex ideas may require complex statements, and we do our students a disservice if we teach them that in every instance "simpler is better," especially if we reinforce this notion with the perceived authority of the computer.

Against this background of generally uninspired applications, a few exceptions stand out. Most advanced is The Writer's Workbench, a package originally developed by Nina MacDonald at Bell Laboratories to reform the jargon of internal technical documents so that they could be comprehended by the general public, to whom Bell will be selling its products under the divestiture. Two enthusiasts for computer-assisted instruction in writing, Katherine Kiefer and Charles R. Smith, negotiated with Bell to market-test The Writer's Workbench at Colorado State University, where the entire freshman class uses terminals to compose papers, submit them to various checking routines, and edit them in response to their instructors' comments. The popularity of this system among students (who like handing in neat papers with fewer errors) and faculty (who like receiving such papers) is creating pressure to make it available throughout the campus (*11*). Bell has begun to market this system and will probably expand beyond the English-speaking world to wherever English is taught. Such popularity, coupled with the corporation's tremendous resources and experience in marketing, conjures up visions of a major corporate force in education. Created outside academe by an organization only tangentially concerned with instruction, The Writer's Workbench and its emulators bid fair to alter many notions of what education is and how it is administered.

Our conventional assumptions about education are being further challenged by computers as humanists install them in their classrooms to teach foreign languages. Here again, the danger is that the methods of the 19th century may be encased in today's technology. Most current programs are no more than flash cards for drill on vocabulary or grammar. Students are promptly informed of their scores and often given randomly generated (but transparently mechanical) encouragement, such as "Nice going, Jean." Almost nothing has appeared in print discussing the possibility of new pedagogical principles and methodologies created by the microcomputer. Still, the ability of a machine to drill students and to respond to them is the foundation of truly interactive instruction, the fulfillment of Mark Hopkins's description of the ideal teaching situation: a teacher and a single student on opposite ends of the same log (*12*).

Fulfillment of the potential of computers in foreign language and other instruction may require the use of versatile mass storage devices like the videodisk. It is not beyond our ability to design a system that will convincingly simulate dialog, adjusting for the age, level, and interests of individual students. Of course, producers of such an expensive system must be convinced that a market can be developed, and academe will not commit its meager resources to a system that exists only in the minds of a few visionaries. Government and foundations, too, are reluctant to devote funds to untried methodologies (*13*).

In the meantime, a small step is being taken by individuals who are teaching the methods of text analysis that must form the basis of any innovative instructional or research techniques. Vinton Dearing at the University of California, Los Angeles, James Helm at Oberlin College, Susan Hockey at Oxford University, Ian Lancashire at the University of Toronto, and Antonio Zampolli at the University of Pisa are among the leaders in the effort to develop and disseminate the new methodology for text analysis. The future holds the promise that not only will faculty research be enhanced by the new technological support, but students will be helped to learn methods as well as content. Thus they will learn better during the years of formal instruction (because they will be acquiring information as they recognize the need for it, not according to "lesson plans") and they will master attitudes and techniques that will encourage life-long learning.

Applications in Libraries and Publishing

Carnegie-Mellon University allows former students to continue to use their microcomputers in accessing the catalogs of the university library from anywhere in the Pittsburgh region. Such an imaginative extension of the traditional library foreshadows even wider utilization of the computer as an information tool. Two functions fall naturally under the aegis of information science. First, the proliferating text databases are enough like books—are in fact books in another form—to be catalogued and stored in a similar way. Until on-line access is a reality, tapes and disks must be housed like other artifacts, and will rapidly exceed the capacity of departments to maintain them and supervise their use. Just as students either read books in the library or check them out for use in their rooms, they will most likely utilize courseware in the same fashion.

There is always the possibility that technology will make these recent inventions obsolete and that students will be able to download both text and programs directly into the memories of their microcomputers, but it is difficult to imagine national centers able to distribute files to millions of students around the country. More conceivable is the evolution of existing libraries into a general resource center for on-site use and for the loan (or cheap copying) of floppy disks for personal use. Networks like the Online Computer Library Consortium (Dublin, Ohio) and the Research Library Information Network (Stanford, California), already functioning to exchange bibli-

ographic information among their subscribers, can expand to include full-text files and programs among their transmissions, and other networks already linking computer centers for transfer of files can also be integrated into a system of interlibrary loans.

Humanist faculty members who use computers to distribute course materials to their students, receive completed work, and exchange memorandums with their colleagues may eventually use computers for dissemination of their research papers. Already computers have been used in long-range collaboration in authorship and prepublication distribution for comment. For papers of narrow interest electronic publication is a cheaper, faster, and more available medium than print. One significant obstacle is that scholars publish as much to impress their superiors as to inform their peers, and superiors are impressed only to the extent that research is certified by the reviewers and editors who screen submissions to print journals. A system of on-line publishing will thrive only to the extent that it serves this function of assuring administrators that papers have been approved by off-campus experts (*14*).

Libraries are finding it impossible to keep up with the number of paper journals that are arising to serve academic specialties, and there are serious physical problems associated with the storage of these materials, including deterioration of the paper, vandalism, and sheer bulk (*15*). The opportunity to locate and read scholarly articles rarely occurs during the working day, and many potential readers of articles are too far from metropolitan libraries to have ready access to the materials they might read if on-line access were available. The emergence of electronic publishing seems an inevitable response to these and other economic and technological forces. Short articles and bibliographic notices may come first, then courseware and other programs, and finally monographs. Whether these materials are read on monitors or are printed at terminals to satisfy our well-established need for a thing to hold may be a matter of personal choice.

Accessibility of research literature through computers will compel us to develop better means of locating specific information. Current searching strategies are so complex and are couched in so much jargon that usually only librarians, already trained in their profession and then further trained in on-line searching, can quickly find specific items. Surely future generations will see in these early methods the same shortcomings we recognize in card catalogs and other makeshifts. Truly useful finding aids must be capable of translating a user's request from natural language into the terminology of the system, and they must do so with no more difficulty for the user than is experienced in tuning in a TV station or dialing a telephone number. Such a system will probably be based on artificial intelligence (AI), the much-sought ability to simulate human thought.

Impressive sums are being spent on AI research by government and industry for purposes far removed from providing humanists with improved research tools. Rather, the hope is to use AI to prevent war or to win any war that occurs. Assuming they are successful and we are able to continue to pursue the truths and beauties offered by the humanities, some of the AI methods developed should facilitate searches for specific information in the humanities. By modem and phone line, any researcher should be able to comb the resources of any library. Not only printed books and journals but any accumulation of materials needed for research must someday be accessible. Rather than flailing about in a welter of information, the researcher should be able to use AI methods either to browse or to guide a personal computer to particular bits of information, even though they may not have been known at the beginning to be necessary or even to exist.

These ambitious expectations are only extensions of what is being tried today. To restrict our objectives for computer applications in the humanities to word processing and drill-and-practice would be to force our thinking into the narrowest channels.

Conclusion

Machines like electronic typewriters, printing presses, and photocopiers are all accepted components of modern scholarship. Computers represent one of the most sophisticated extensions of man's abilities yet developed, and should be integrated as fully as possible into the array of resources we draw on in our intellectual activities.

Such democratization of the computer will not be easy to achieve, however. Computers are still controlled largely by technocrats, who tend to be reluctant to share them and who benefit from perpetuating the myth that computers have exclusively scientific, technical, and clerical functions. The universities that provide microcomputers to their faculty are predominantly polytechnics, where humanists staff the service departments and humanist research is not highly esteemed.

Perhaps the greatest obstacle to full utilization of the computer by humanists is their centuries-old tradition of independent work. Ingrained in our collective mind is the image of the solitary humanist, surrounded by piles of open books and scribbled notes, mining for one more quotation to provide a footnote. Humanists are having difficulty in adjusting to an environment in which cooperation may be the best path to success. Whereas articles by single authors are still often the foundation for successful careers, computer software developed in the same way is not likely to achieve much status for itself and its author. The labor required to write programs is usually far too great for individuals who have other demands on their time. Similarly, analysis of large data bases such as are now accessible is seldom manageable by "loners."

Fortunately, the humanist making the effort to adjust has as aids programs like The Writer's Workbench, Epistle (being developed by IBM), and WANDAH (being marketed by Scribner's). Such programs are likely to produce two benefits for humanists. The first is a tool for analyzing belles lettres. With the continuing extensions and refinements that must result from widespread adoption, these programs can become ever more sensitive instruments for identifying and displaying particular aspects of written communication. It may be easier to analyze levels of usage (slangy, colloquial, formal), avoidance of pronouns, excessive qualification ("rather," "quite," "very," "at least"), and similar traits when they are highlighted on a computer terminal. With intelligent programming, attention can be called to the predominance of certain vowel and consonant sounds. Even the idea that we hear prose as we read it may enrich our perception of the tie between the written and spoken forms of language.

The second benefit is the liberation of humanists from a drudgery that contributes nothing to teaching or research. Almost every humanist, whether specializing in literature, art, music, history, or foreign languages, must assign and read a quantity of student writing. The load is perhaps heaviest on English teachers, who may have to read up to 100 essays a week, noting punctuation, diction, spelling, sentence structure, and organization in addition to judging content. Anything that legitimately lightens that burden, especially if it also improves student

writing, leaves time for the reading, thinking, and writing that should occupy the bulk of a humanist's time. If the prose analyzers being developed and marketed will contribute to shifting the balance from mechanical drudgery to intellectual liberty, then they are to be welcomed.

Perhaps the major effect of the new technology will be to reduce the current distinction between research and instruction. Faculty bring to their investigations the knowledge and perspective their students are only beginning to acquire. But the distinction between them should be one of degree, not kind. Absolute knowledge is changing too fast to be taught once for a lifetime; it is essential therefore to master techniques of learning for lifetime use. Of all our inventions, perhaps none has come closer to being the ideal tool to provide that mastery than the computer, now on the brink of proving its worth to the collection of values and principles we call the humanities.

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Personal Computers on Campus

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Summary. Colleges and universities are becoming test beds for the much-heralded "information society" as they incorporate a new series of information technologies. These include on-line databases, magnetic and optical data storage, digital telecommunications, computer networks, and, most visibly and dramatically, personal computers. The transition is presenting administrators and faculty with major challenges, however. This article discusses some of the issues involved, including access to computers and to computer networking, managing the transition, and the educational uses of personal computers. A final section discusses efforts at Massachusetts Institute of Technology, Brown University, and Carnegie-Mellon University to shape a new-generation personal computer, the so-called "scholar's workstation."

In 1978, the University of Washington's vice provost for computing, Robert Gillespie, bought a few of the new Commodore PET home computers and loaned them out to faculty members. "We just wanted them to try the machines for a while and see if there was anything they could be used for," recalls Gillespie, who is now a private consultant on computing in higher education. Then he laughs: "We never could get them to give the things back."

It was just a hint of what was to come. No one has made an accurate count of all the Apple II's, IBM Personal Computers, Macintoshes, and other such machines that have appeared on American campuses during the last few years (Gillespie estimates hundreds of thousands), but there is little doubt that academia has taken to the personal computer (PC) with exuberance. Indeed, it is striking how rapidly computers have spread beyond their traditional enclaves in science and engineering. Business students are using spreadsheets to do their homework. Historians are using filing programs to manage their bibliographies. Social scientists are using database management systems and statistical packages to reduce their data. Dance students are using Apple II graphics to notate choreography. Drama students are using IBM PC's to design stage sets and lighting plans. And everyone is processing words, from students doing term papers to assistant professors revising journal articles.

But the PC is more than just a box on a desktop. Together with a host of other information technologies, including on-line databases, optical data storage, digital telecommunications, and computer networks, the PC is transforming the campus into a microcosm of the much-heralded "information society." It is no accident that industry giants such as IBM and Digital Equipment Corporation (DEC) have invested tens of millions of dollars in university research projects, both to develop software for a new generation of high-powered personal computers—known generically as "the scholar's workstation"—and to find out what can be accomplished in a network of such machines.

In addition, the PC's have accelerated the on-going process of computer decentralization. From the 1960's, when the word "computer" meant a mainframe and an air-conditioned, professionally staffed computer center, through the 1970's, when the more affluent research groups started buying VAX's and other minicomputers to bring their data processing in house, and continuing in the 1980's, when the PC's started arriving, the control of computational resources has passed more and more into the hands of the users.

Finally, the PC and its associated information technologies seem to be triggering some profound changes in the educational process and in higher education as an institution—although no one is quite sure yet what those changes will be.

Of course, one could be forgiven a certain skepticism about all this. "Historically, these things go in waves of enthusiasm, followed by retrenchment

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