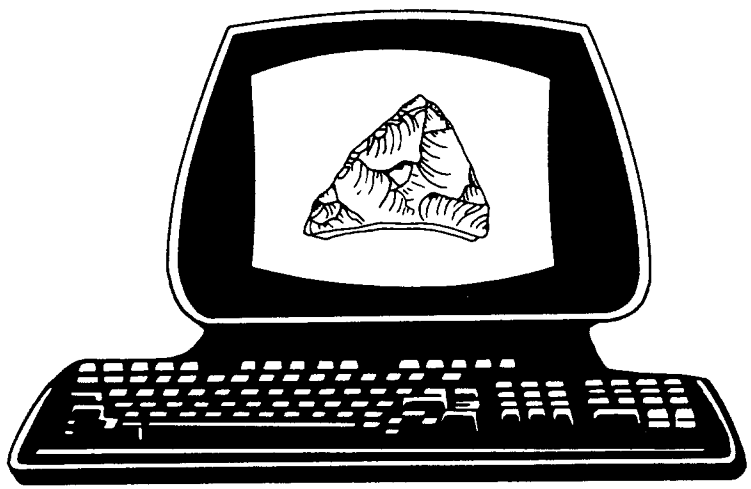
ADVANCES IN COMPUTER ARCHAEOLOGY



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HARDWARE AND SOFTWARE COMPLEXITY IN COMPUTERIZING ARCHAEOLOGICAL PROJECTS

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Recently, one of us (Dibble 1987) has outlined a system for quick, accurate retrieval of artifactual data in the field. In another article (Dibble and McPherron in preparation) we have gone further and outlined many broad issues and problems concerning the use of computers for data acquisition, retrieval, and presentation in a computer system for archaeological projects. This article explores more detailed aspects of hardware and software that are basic to the development of such a system, illustrated with examples from our own work for the Middle Paleolithic sites of La Quina and Combe-Capelle in southern France.

AN OVERVIEW OF THE LA QUINA AND COMBE-CAPELLE SYSTEM

The computerized system in use at these projects can be broken down into three major functional areas of data acquistion, centralized data storage, and data retrieval and presentation. These functions are represented schematically by the three major horizontal divisions of the flow chart presented in Figure 1. The first of these is further

subdivided into the minor components of field, laboratory, and image data acquistion. The field process begins with the measurement of the three dimensional coordinates of artifact provenience using an electronic theodolite. These data are passed to a computer, via an interface, and supplemented with other observations, such as square, archaeological level, and excavator. A small printer produces a tag with this information for each artifact. In the laboratory, fauna and lithics observations are entered directly into small computers and any measurements made with electronic calipers are also passed to the computer via an interface. Images of artifacts are recorded using a video camera connected to a computer with a digitizing board. Site maps and photographs are also digitized for inclusion in the central database.

Field, laboratory, and image data are eventually transferred to one computer where they are archived, validated, and integrated into a centralized database. This is the second major horizontal division of Figure 1. The third major division corresponds to data retrieval and graphic presentation. This involves the use of two high resolution, color monitors, one for the display of artifact images and the other for displaying artifact measurements and observations. Where possible, the latter are displayed in the context of square, section, and site plans using color to explore possible spatial relationships among major artifact classes or archaeological levels. Plans can also be reproduced on a color plotter. The Appendix contains a complete list of the commercially available hardware and software used in the La Quina and Combe Capelle system.

HARDWARE ISSUES

There may be considerable variability in the hardware components actually used between and within each functional division of the La Quina and Combe-Capelle system. But, there is a similar structure to the different components, seen as the vertical columns in the upper part of Figure 1. For example, in each subdivision of data acquisition there is a specialized instrument used to collect the data. This instrument is connected, via a hardware interface, to a computer which will interact with the operator and temporarily store the data. This data acquisition computer is then connected to a central computer, again via an interface, and the data are transferred once more. The following discussion is organized along these vertical columns.

Instruments

Theodolite. There are several features which distinguish theodolites appropriate for use in an archaeological computer system. First, the theodolite must come equipped with an electronic distance measuring device (EDM). This measurement is necessary for the calculation of the three Cartesian coordinates of the objects. Second, some EDM theodolites display these measurements but do not transmit them directly to a computer or data collector. It is much more efficient when the theodolite itself is able to transfer them to a computer (Korsmo et al. 1985, Sanders and Sanders 1985). Last, a theodolite must be accurate, but precision to five or ten seconds of arc is sufficient for artifact point proveniencing within 100 meters of the instrument. The La Quina and Combe-Capelle system uses a TOPCON GTS-3B which satisfies all of these requirements (Dibble 1987).

Calipers and Other Laboratory Instruments. Size and accuracy are two basic considerations affecting the selection of electronic measuring devices for the laboratory, including calipers and scales. Caliper sizes vary from small enough to measure lithic debitage to large enough to measure large ceramic vessels, and electronic micrometers can have accuracies of 0.001mm. Again, electronic accuracy and size are not as important as an instrument's ability to communicate measurements to a computer. The relative ease or difficulty with which this can be accomplished will determine which instruments can be used in a computerized laboratory situation (Korsmo et al. 1985).

Camera. Video cameras are either black and white or color. Black and white video systems are less expensive than color ones, but the small difference in cost is more than offset by the increase in the amount of information collected. In this sense, color systems are more cost effective. The reason lies in the difference between spatial and color resolution. Spatial resolution is the number of lines and columns the video system (camera, digitizing board, and display unit) recognizes. Color resolution is the number of colors distinguishable at the intersection of a row and a column. The storage requirement for an image is the product of its color and spatial resolution. For a given level of spatial resolution, however, the storage requirements are only doubled when the color resolution is increased from 256 shades of black and white to 32,768 shades of color. This means that 128 times the information is available for only two times the storage cost, which makes color systems more cost effective. Of the three components of the video system, increasing color resolution affects only the digitizing board, while increasing spatial resolution affects all of them. To realize the full spatial resolution of a high quality television display, a video camera superior to those suitable for home use is needed. The resulting images are displayed on analog monitors, not standard digital computer monitors (though some monitors can display either). The La Quina and Combe-Capelle system uses a studio quality, color JVC camera, a TARGA-16 digitizing board, and a Sony color television monitor.

Plotter. Plotters are divided into size classes A through E. E size plotters accept 36 by 48 inch paper while A size plotters only accept 8 by 11 inch paper. Plotters of each class vary in the number and types of pens they support. Fiber tip pens provide vivid colors but are slower than ball point and liquid ink pens. Accuracy and step size determine a plotter's ability to draw sharp lines. Communications and programmability, while extremely important, are less useful in separating plotters since nearly all support the Hewlett-Packard Graphics Language (HPGL) and standard RS-232C communications. The La Quina and Combe-Capelle system uses an inexpensive B size (11 by 17 inch), HP-7475 color plotter with fiber-tip pens.

Instrument Interfaces

It is always difficult to transfer data from an instrument to a computer. The HP-71B computer, for instance, uses a proprietary data communications format called HP-IL. The theodolite uses an entirely different RS-232C communications format. Both use different kinds of cables. It is physically impossible, therefore, to connect them directly to one another. To do this requires a special intermediary device, called an interface, which has connectors for both the theodolite and the HP-71B and acts as a translator between the two. Similarly, an interface is needed to transfer data between the electronic calipers and the HP-110 computers.

While not exactly an interface, the digitizing board used in video data acquisition is needed both to connect physically the camera and the computer and to translate the analog signal of the former into numbers for the latter. Likewise the digitizing board translates the digital image back to analog for displaying on a television monitor. The quality of an image digitization board is directly related to its spatial and color resolution. Boards with high resolution, particularly color resolution, will accomplish the translation process without noticeable image degradation. As mentioned, the cost of resolution is storage. Image compression boards are designed to work with digitization boards to minimize the storage cost of image resolution. The ALICE compression board compresses the image after the TARGA-16 digitizing board has translated it to numbers and decompresses it before the numbers are translated back to an analog signal for the television monitor.

Computers

Besides decisions concerning the instrument types, there are a number of factors affecting the selection of a computer, whether for data acquisition or primary data storage and retrieval. The two most important factors are portability and compatibility. Portability is a limiting factor in such important considerations as a computer's ability to store large amounts of information, its ease of use, and its reliability. Computer technology is quickly improving the abilities of computers at every level of portability. Computer compatibility is as important as portability. It is very advantageous to stay with popular brands of equipment, in that they will always have large support networks involving many companies that manufacture related hardware and software options. This creates many more opportunities and choices for the user and helps to ensure the longevity and continued expansion of a computer system.

Field Data Acquistion Computers. Several theodolite manufacturers make data collectors specifically for their theodolites. These specialized data collectors, while highly portable, are not always the best choice for archaeologists in that the standard programs are designed primarily to meet the needs of surveyors interested in topographic or architectural features. While these needs do exist in archaeological situations, archaeologists may also be interested in point proveniencing artifacts and other strictly archaeological tasks. Unfortunately, writing new programs for these data collectors can be difficult due to their use of arcane programming languages which are limited in compatibility. Alternatives are available, such as the HP-71B computer. This computer is as portable as specialized data collectors but much more compatible with a variety of products. Not only does it allow programs to be written in a version of the familiar BASIC language, but it also allows for easy connections to other types of equipment, including printers and external disk drives.

Laboratory Data Acquisition Computers. Laboratory analysis of archaeological finds requires a different computer solution. The HP-71B computers are not suitable for the laboratory for two important reasons. First, the digital calipers could not communicate with the HP-71B. Second, laboratory analysis involves

recording more variables which requires more memory capacity than the field computers can supply. Laptop computers, though slightly less portable, can store significantly more information than the HP-71B (Katz and Katz 1985, Korsmo et al. 1985). The HP-110 laptop computers used at La Quina and Combe-Capelle support communications with the calipers, and they are MS-DOS compatible with larger personal computers and are also compatible with the same Hewlett-Packard external storage devices and printers used with the HP-71B. Because laboratory analysis did not require the abilities of a larger personal computer, several laptops could be obtained for the price of one personal computer.

Image Data Acquistion, Data Storage, Retrieval, and Presentation Computer. Centralized data storage requires a singe computer with storage capacity for all data created during field and laboratory data acquistion. The computer which holds the main database is also required to retrieve and present the data quickly, preferably using high resolution, color graphics. A great many computers, including a few laptop computers, are capable of meeting these needs. But it is not just size and power that are the main considerations. The La Quina and Combe-Capelle system, for example, requires a computer for image data acquisition, which utilizes a TARGA-16 image digitizing board. This board will only work with IBM-AT class computers and cannot be installed on the smaller portable computers. At present it will not work on an even more powerful machine, such as the IBM PS/2 Model 80. Thus, the IBM-AT gives the speed, storage capacity, graphics flexibility, and image compatibility required by the La Quina and Combe-Capelle system. This illustrates the complexity that can be involved in choosing any component in this system (Kampffmeyer 1986).

Computer Interfaces

As with instrument to computer communications, interfaces are often required to connect computers to other computers. For instance, an interface is required for the HP-71B to transfer data to the IBM-AT, which uses the same standard RS-232C format as the theodolite, but cables that are completely different from the theodolite. And an HP-IL interface board allows the HP-110 computers to communicate with the IBM-AT. In other words, virtually every connection between any two devices or computers requires an interface. Unfortunately these essential interfaces tend to be very expensive.

SOFTWARE ISSUES

Selecting a program involves two major considerations. First and most fundamental is its hardware compatibility. Second, a program must satisfy particular needs or functions, such as data acquistion or data retrieval. There are a series of other considerations, such as efficiency, easy of use, compatibility, and flexibility, which, though perhaps not as important as the first two considerations, are nonetheless of prime importance.

Hardware Compatability

The most basic consideration in hardware compatibility is between operating systems. MacIntosh, IBM and Hewlett-Packard 71B series computers use mutually exclusive operating systems that prevent programs which run on one of them from running on another. Given a type of computer and operating system, software options can involve special hardware requirements such as high

resolution, color monitors, graphics cards, pointing devices, additional memory, various dedicated boards, and math coprocessors. Most programs will specify their minimal hardware requirements and suggest options which contribute to their effecient use.

Functional Considerations

There are a number of different functions involved in the computer system at La Quina and Combe-Capelle. First, there are the data acquisition programs, though different ones are used for each class of data (e.g. field artifact provenience, lithic and faunal analysis, artifact images). There are different communications programs that transfer data from one computer to another. For each class of data there are special programs to verify the integrity of the data. And there is no limit to the number of programs that might be used for obtaining lists, producing plans, producing and analyzing artifact counts, and so forth. The multiplicity of functions in an archaeological project makes it virtually impossible to have one software solution. Due primarily to memory limitations, any program capable of accomplishing so many functions will undoubtedly not be very good at any one. Moreover, the singular needs of archaeologists, combined with the use of specialized equipment, generally preclude the use of commercial software.

There are some important exceptions, however. Communications programs are usually available for transfering information between most computers. A commercial program called DATACOMM, for instance, transfers sets of field data from the HP-71B to the IBM-AT. Another communications program, HP-LINK, transfers laboratory data from the HP-110s to the IBM-AT. Many commercial database programs are

CONCLUSIONS

A computer system for archaeology requires multiple hardware and software components that must work together. Careful attention, therefore, must be given to the selection of each component. If properly designed, however, a system with multiple components has an important advantage: when new technologies or programs make system components obsolete, they can be replaced individually without threatening the viability of the system.

Clearly, an archaeological computer system can not be constructed solely from commercial software. The variety of field situations, field and laboratory equipment, and research questions requires programs written especially for archaeologists. Given that most archaeologists are not programmers, it is very important that computerized archaeological projects have from the beginning a computer specialist involved in its design. But there are also serious issues of how those specialists are to be trained and what standards can be developed for their certification.

In our view, what the field needs most at this point is not another computer program for solving some particular task. What we need is to better understand the overall structure of the methods of archaeological research and to outline the general sorts of problems and potential solutions. Thus the system presented here should only be taken as one example of how a computer system can be mapped onto the needs of a particular archaeological project.

APPENDIX

HARDWARE	SOFTWARE
Field	
TOPCON GTS-3B Theodolite with EDM	
Large Battery with Charger	
Small Battery with Charger	
1" Prisms	
HP-71B Computer	DATACOMM 82488A
HP-71B HP-IL Module 82401	
HP-71B 32K memory modules	
HA-2 Interface	
HP Thermal Printer/Plotter 82162A	
HP Disk Drive 9114A	
Laboratory	
HP-110 Computers	
Fowler Calipers	
Fowler Caliper Interfaces	
Video System	
JVC Camera TK-870U	
AT&T TARGA-16 Digitizing Board	TARGA Image Library
Telephoto ALICE Compression Board	ALICE Compression Library
Data Storage	
IBM-AT with 20mb Hard Disk	dBASE III+
HP-IL Interface Board	HP-LINK
EGA Graphics Card	

Data Retrieval and Presentation

NEC MultiSync	QuickBASIC
Sony Color Television KV-1311CR	dbLIB BASE Library
HP-7475 Color Plotter2	
Microsoft Mouse	Microsoft Mouse Library

REFERENCES CITED

Dibble, Harold
1987 Measurement of Artifact Provenience with an Electronic Theodolite Journal of Field Archaeology 14:249-254.

Dibble, Harold and Shannon McPherron
1988 On the Computerization of Archaeological Projects. In Preparation.

Durand, Stephen and Jonathan Davis
1985 Archaeological Computer Applications with an IBM-PC Advances in Computer Archaeology 2:21-37.

Kampffmeyer, Ulrich
1986 ACROS A Documentation and Database System for the Use in Archaeology Advances in Computer Archaeology 3:1-39.

Katz, Susana and Paul Katz
1985 Automated Data Recording in Archaeology Advances in Computer Archaeology 2:1-20.

Korsmo, Thomas, Fred Plog, Steadman Upham and Linda Cordell
1985 An Application of Computers and Computerized Devices in the Field Advances in Computer Archaeology 2:31-42.

O'Brien, Helen and Charles Redman
1985 The Microcomputer: An Effective Field Tool? Advances in Computer Archaeology 2:43-67.

Sanders, John and Peggy Sanders
1986 Archaeological Graphics Services' Remote Mapping System Advances in Computer Archaeology 3:40-55.

The La Quina and Combe-Capelle System

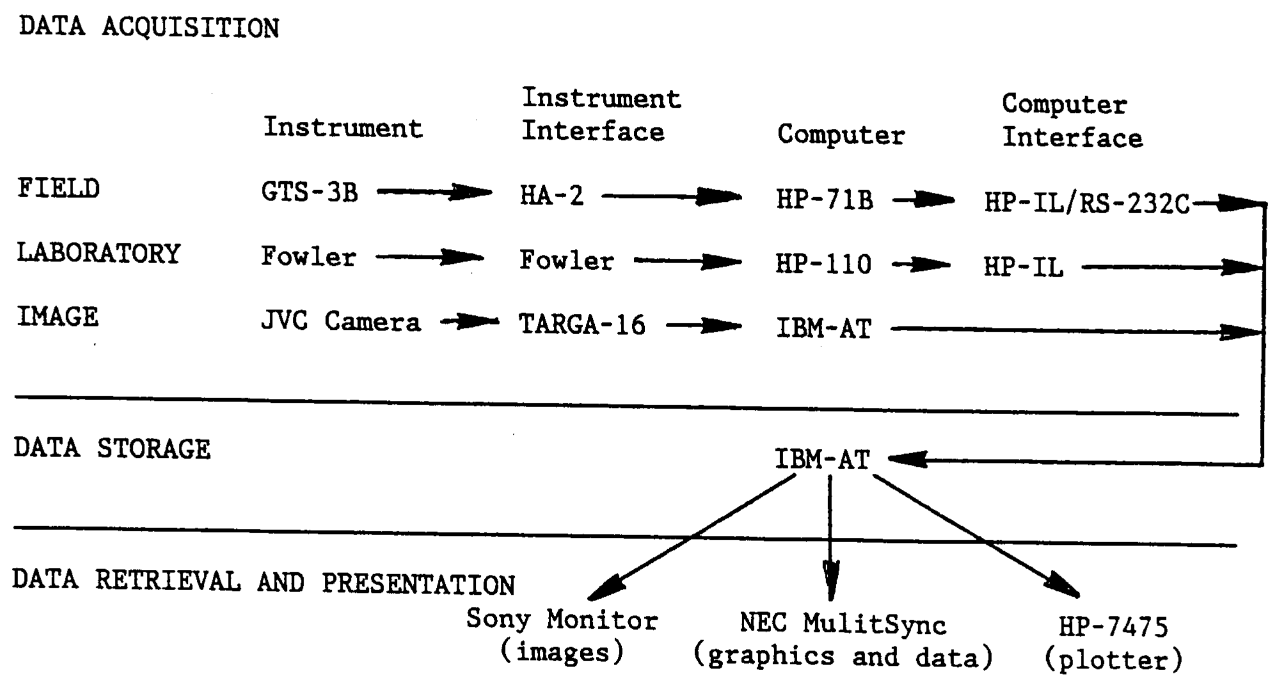

Figure 1.