TECHNICAL NOTE

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Microcomputers in Forensic Science

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ABSTRACT: In the last few years, there has been a revolution in computer technology. Small, inexpensive, and powerful microcomputers are assuming the work previously done by expensive and limited minicomputers and manual systems. New uses of microcomputers and several forensic science applications of user definable software is discussed. This paper also reviews basic computer systems and cautions for prospective users.

KEYWORDS: forensic science, computers, software, database management

In past years, the computer was considered an expensive luxury to all but the largest forensic science offices. This was due to the rarity, great expense, and complicated technology needed to support "the computer." Today this situation has changed. Powerful yet small computers are available inexpensively and can be operated with little prior training. The $200-$800 desktop or brief case computer is available in most communities and packs the same power as the million dollar computers of a decade ago. This report will focus on the new technology of micro- and super microcomputers and their applications to some common aspects of the forensic sciences.

Problems with Data

One problem with modern forensic science is the increasing mass of data that is produced. Lab test results, evidence, identifications, mass disasters, missing persons, staff scheduling, reports, inquiries, inventory maintenance, public-media relations, and interagency communications take time and generate data that must be collected, calculated, compared, stored, and recalled. As the science becomes technologically more precise, increasing amounts of data are generated. This adds to the pressure and workload of the professional. Unfortunately, this large amount of data requires more staff specialists, and the growth in personnel intensifies communication problems. It is now common for several individuals to be working on the same case, each within his or her own speciality, and with limited communications among each other—there is a higher probability that important case data may "fall through the cracks." Computer automation can help reduce this problem.

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Manual Systems

Manual systems require people or "dumb" machines (such as, photo copiers, telephones) to collect and process data. File cabinets store records, secretaries type (and retype) letters and recall information. Most of the forensic science professional's time is spent in document preparation: reading and sorting files, gathering facts and statistics. This leaves less time for "productive" investigation and case solving.

Personnel problems hamper many manual systems, especially with intradepartment communications situations. Asking a testy clerk to find several lost files at 4:30 p.m. on Friday is an excellent example. There have been many cases that have been compromised by personality conflicts and human error. Poor penmanship, conflicting codes, nonstandardization of forms and records, misspellings, lost records, and so on are all problems attributed to human nature and individuality.

Minicomputer Systems

One of the first attempts at reducing the problems of manual systems was minicomputers. In the 1960s and 1970s, these large, expensive machines were used to file, sort, and compare data in select cases. The "minis" were fast, thorough, and efficient, and they produced meaningful results in a readable form. Situations involving missing persons, criminal and personal records, mass disasters, and document filing were greatly helped by the rapid sorting and matching capabilities of these computers [*1*].

Unfortunately, there were drawbacks with minis. The equipment was large, often refrigerator-sized. It was expensive to buy and operate. Great amounts of electric power and climate controlled rooms were needed. Software (the program used to operate the computers) was scarce and limited. Often you would have to change your office routine drastically to use the computer. Because of its complexity, technicians, service personnal, and programmers were needed to keep the machine running. Special telephone connections or wiring were required for remote terminal use. Interruptions in service were frequent, and often one would hear "the computer is down" once or twice a day. All operations would halt until service was restored. Another problem with the minicomputers was interoffice communications. In order to send data from one computer to another, it was necessary for the computers to have similar Applications and Disk Operating Software (DOS). Few systems would exactly match, thus making data transmission between computers difficult. But the greatest detriment to minicomputer use was the cost, which few offices could afford. There were only a handful of offices, in the larger cities, able to afford a $250 000 mini with service and supply costs in excess of $20 000 a year.

New Computers

Fortunately, this situation has now changed.

The micro- and super microcomputers have radically changed the use of computer systems in the forensic sciences. Though "micros" are smaller than the minis, they are almost as fast and powerful. The new 16-bit supermicros have crossed the line that once separated micro- from minicomputer (Fig. 1). The big advantage of micros is in the low cost ($49 to $9000), ease of use (do it yourself manuals), minimal service, minimal power and environmental requirements, and small size (cigar box to TV set size). The peripherals (printers, disk drives, modem, monitors) and software are also inexpensive and durable. A full computer system including monitor, printer, modem, computer, cables, and software can be purchased at any one of 2000 local North American computer stores for well under $3000. Service is inexpensive and consists of circuit board swapping, which can be done at local computer stores or during economical service visits. Micro service contracts cost between $10 and $30 per month, a fraction of the cost of a minicomputer contract [*2*].

FIG. 1—*IBM-PC-AT Supermicro computer with monitor screen, 20-megabyte hard disk, floppy disk drive, and keyboard (Compliments of International Business Machines, Inc.).*

The size of micros varies. Many are standard TV set size but there are a growing number of portables which are notebook sized, operate on batteries, and can be taken into the field (Figs. 1 and 2). Data can be transferred to other computers (larger and smaller) over normal telephone lines (such as, phone booths) by the use of modems (Fig. 3).

Because of the low expense, abuse resistance and ease of use, microcomputers can be purchased, loaned, or rented by the day, week, or year in most communities. These options do not exist for the mini computer.

Software, the written programs that operate the computer, is quite varied and plentiful (for example, today there are over 1000 different data base management programs for micros). Prices range from free to $500 for a program that would cost a mini computer user thousands. Because there are many micro users, most better known, off-the-shelf software packages are well tested (debugged). These programs are easy to learn, and many come with training software that allows the computer to educate you and your staff.

There is a wide variety of peripherals for micros. Floppy disk drives can store up to 1.5 megabytes of data in memory (1.5 million characters) (Fig. 4). Hard disks (shoe box size) will store up to 40 megabytes of data (Fig. 1). Printers ($200 to $2000) can print multiple letters, charts, or drawings in color. Digitizers ($200 to $1000) can analyze drawings, tracings, photos, and X-ray images (Fig. 5). The data produced can be stored, sorted, and redrawn in different sizes automatically. Lab equipment can connect (interface) with the micro by using A/D circuit boards ($200 to $1600) (Fig. 4). Card readers and optical scanners ($700 to $1200) can convert written data into statistics and calculations rapidly [*2*].

Micros can be connected to each other or to larger computers through network systems ($100 to $3000). Research with the national databases, statistics, and communications between individuals or departments can be accomplished by making a single phone call.

Because of the ease of use, low cost, and wide selection of software (programs) and hardware (the computer equipment), all forensic science personnel can have access or even own a useful computer.

FIG. 2—*The Portable, a 4-kg (9-lbs) personal computer with a battery powered printer. The Portable measures 330 by 254 by 76 mm (13 by 10 by 3 in.) (Compliments of Hewlett-Packard Co.).*

FIG. 3—*A 1200 Baud modem that links computers over regular telephone lines (Compliments of U.S. Robotics, Inc.).*

Three Applications

Some of the most useful applications of computers can be found with database management, spreadsheet, and communications software. These programs are available at most computer stores or by mail order. They are inexpensive ($20 to $500) and user definable. A user definable program allows the user to select (define) his or her own data parameters and organization. You may use your own words and relationships to design a "custom" program without knowledge of programming. After you select your options, the computer will generate a program for your specific needs [*3*].

FIG. 4—*Bilog System.* Left to right: *thermal printer, two floppy disk drives, Apple II computer, monitor, amplifier, analog to digital (A/D) circuit system for lab equipment (Compliments of Cyborg, Inc.).*

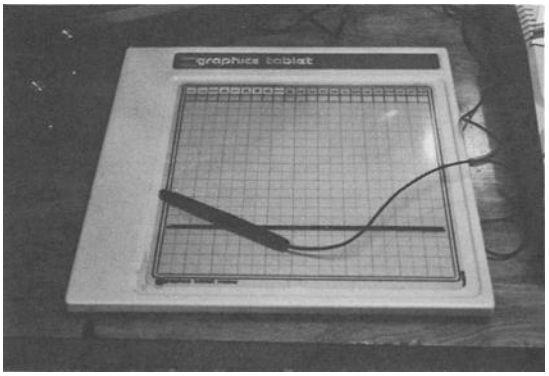

FIG. 5—*A digitizer with stylus (reprinted with persmission from Andent, Inc.).*

Data Base Management Systems

Data Base Management System (DBMS) Programs have two sections. The first helps you design a program. The second section "runs" the program you designed. A filing system is an example. You may instruct your database management program to create a file with five or more categories (fields), for example: name, address, phone, identification number, and description.

Computer: Do you want to create a new file (yes/no)?
Operator: yes.
Computer: How many categories (fields) do you want?
Operator: 5.
Computer: What shall we name them?
Operator: (1) name,
(2) address
(3) phone
(4) ID number, and
(5) description.

Computer; Thank you. Your file system can hold 2500 records. Would you like to:
(A) add data,
(B) change data,
(C) delete data,
(D) list records,
(E) sort records,
(F) search records,
(G) print records, and
(H) exit.

The computer will create a file system based on these categories which will allow you to add, change, delete, sort, and select data in any category and print the results on screen or on paper (hard copy) (Fig. 6). Depending on the power of the computer, measured in terms of disk storage and kilobytes of Random Access Memory (KRAM), you can store several hundred to over 30 000 records [*4*].

Potential uses include case files, inventory, personnal records, case-law support, literature files, mail and phone lists, and financial files.

Case Files

Because the DBMS software can be quickly custom designed by the casual user, a specific case file system can be created for every unique situation. It is not necessary to adapt a manual system to the computerized model when the computer will do the customizing automatically. These files can list names, leads, people working on the case, and their progress. Phone numbers, personal communications, court records, lab reports, and any other significant information can be listed in the data base by field, sorted, edited, and printed on hard copy whenever needed. These records can be duplicated in minutes, allowing all individuals who have access to the computer an organized overview of the case as it progresses.

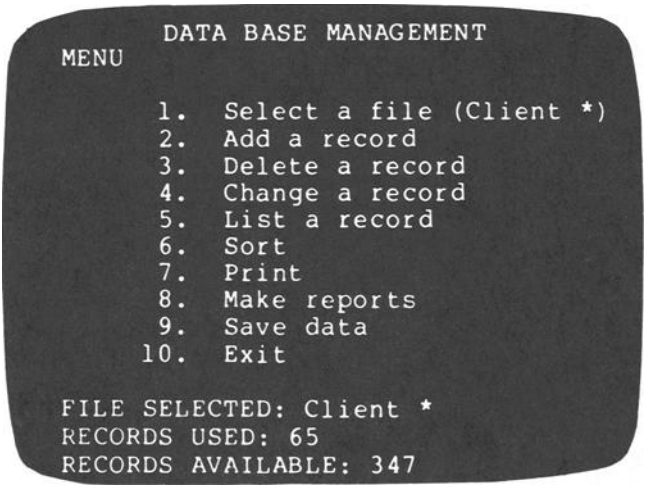

FIG. 6—*Monitor screen of a database management program (reprinted with permission of Andent, Inc.).*

Inventories

Inventories of supplies and evidence can be made using the DMBS. Each item can be assigned a record with fields describing dates, quantity at hand, reordering information, costs, frequency of use, and personal comment data. Evidence can be inventoried using fields identifying case, names, object classification (for example, firearm), location found, and so on.

Personnel Records

Personnel records can be organized using a DBMS so that each person on staff has a record with fields that includes name, address, phone numbers, family, training and experience, education, cases assigned and their progress, vacation schedules, performance, and any other information deemed important.

Case Law

Case law support often involves researching and retreiving great volumes of information. In some complex cases, thousands of documents and regulations are involved. Keeping track of this information is a difficult and time-consuming task. A DBMS can file this data. By having the computer search for keywords and document and reference selection, chronological sorting and searches can be quickly done for any courtroom situation. The rapid selection of relevant data out of thousands of documents is one of the prime advantages of computerization.

Mail and Phone Lists

Mail and phone lists are excellent applications for DBMS software. Each record can represent an individual or organization with name, address, phone number, and other data as fields. Editing, sorting, and mail label capabilities can produce mailings or name lists quickly and inexpensively. DBM's are very flexible, easy to use, and possess applications limited only to the user's imagination and the storage capacity of the computer.

Some of the more popular DBMS programs are PFS file, DBase III, Symphony, and Revelation.

Spread Sheets

Spreadsheet programs are large electronic ledger sheets equipped with the capability to do a wide range of computations automatically. The spreadsheet consists of intersecting columns and rows. Each intersection is called a cell which can contain a number, a mathematical formula involving other cells, or a label. The contents of each cell is determined by the user. The computer can scan across the spread sheet, sorting, searching, printing, or editing data. Spread sheet programs for smaller micros involve a matrix of 63 columns by 256 rows (16 896 cells) (Fig. 7). Supermicros have the capacity of 256 columns by 2000+ rows (512 000 cells) [5].

Applications include statistical ledger sheets, evidence logs, mass disaster and ID grids, staff schedules, physical anthropology measurements-calculations, and any other application that requires the use of a large amount of sortable numeric data. An example of the spreadsheet's usefulness can be seen in a mass disaster application. A grid can be made that reflects the number of possible victims, their ante- and postmortem records, including individual teeth, dental restorations, finger prints, clothing, medical history, jewelry, body location, families, exam data, and other parameters.

The grid can be automatically searched for matching cells (for example, same blood type,

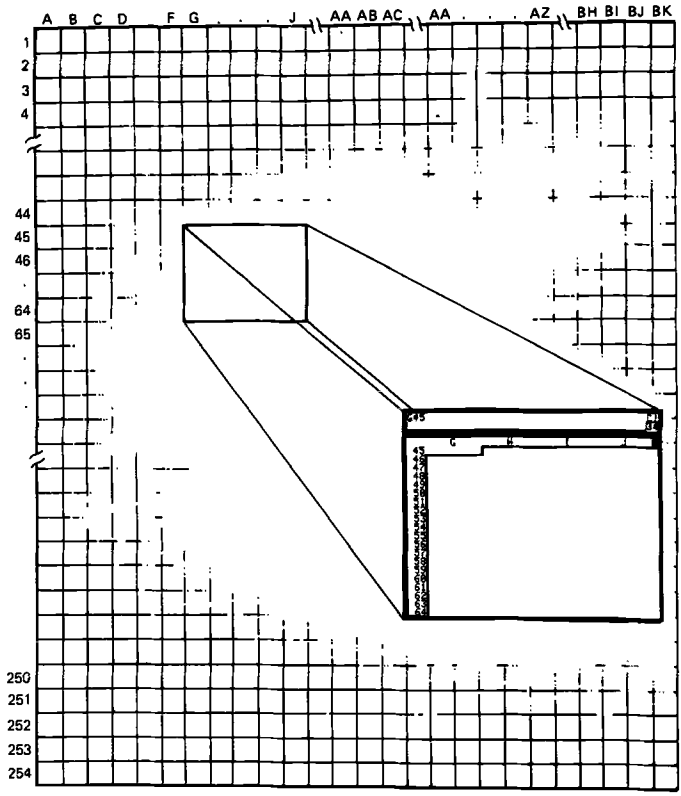

FIG. 7—*A Visicalc Screen superimposed over a representation of the entire spreadsheet (from* The Visicalc Book. *Reprinted by permission of Reston Publishing Co., a Prentice-Hall Company, Reston, VA).*

dental restorations) and a comparison quickly made. Large numbers of cases (for example, the Thompson Canyon disaster, Argentina's "dirty war" victims) can be handled and quickly matched, even with fragmentary data.

This information can be quickly calculated (4 min), compared, and matched. The benefit of such a program using a micro is that the novice can prepare this program application in less than 10 min on a notebook-sized, battery-powered micro at the disaster site (Fig. 2). Printouts, graphs and charts can be produced, and data can be transferred to other computers (micro and mini) over normal telephone or satellite systems using the DIF spreadsheet data standard and modem (Fig. 3). Data can be mailed on a duplicate floppy disks.

Ledger sheets and evidence logs can be easily created with the use of a spreadsheet program. The item, record number, or amount(s) can be inserted into adjoining cells. They can be computed, edited, averaged, statistically analyzed, and printed by the program. Graphs and charts can be drawn. Because there are thousands of cells, most large inventories and budgets can be accommodated by even a small microcomputer.

Physical anthropology often requires comparisons and calculations of extensive numeric tables to determine stature, age, race, and sex of the individual. Complex multivariate calculations can be time-consuming and costly. Spreadsheet programs can speed this process by having the computer do the mathematics, searches, and comparisons, It can also be helpful in quickly assessing probabilities and extrapolations (such as, what would be the change in the victim's stature if this broken humerus was 2 mm longer than what we first estimated).

Some of the more popular spreadsheet programs are Visicalc ($50), Lotus 1-2-3 ($400), and Supercalc ($150).

Communication Programs

Communication programs are one of the most useful applications for the microcomputer. Most micros can interface with a modem ($75 to $500) (Fig. 3), which will link the computer to any other computer over the telephone lines. Modems with speeds of 300 and 1200 Baud (30 and 120 characters per second) can use normal voice lines. Modems with faster communication speeds (such as 2400 Baud) must use specially dedicated lines for data transmission [*6*].

Different brands of computers can exchange data over the modem. Records, files, graphics, and raw numeric data can be quickly telephoned around the world. It is an ideal way to move large amounts of data inexpensively in a short period of time. "Intelligent" modems can code and decode for security and make computer contact automatically any time of the day or night. You need not be in attendance. The micro can serve as a teletype, a direct terminal to Western Union, or an access terminal to national data bases.

To access any computer database in the world, you need only dial the telephone number and give an access code. Many modem-computer systems will even automatically dial the numbers for you. Access to databases allows you to do research at your home or office. Data firms such as Dialog, BRS, Source, Delphi, and Compuserve will connect you to libraries, bibliographical data, new services, scientific abstracts, on-line journals, airline schedules, and hundreds of other databases for $5 to $28 per hour [*7*]. You can even order supplies, airline tickets, and do your banking by using your micro [*2*]. Working after hours presents little problem with a portable micro that you can take home evenings.

Another great resource available through modem is the computer bulletin board systems (CBBS), in which thousands of individuals (with computers and modems) can communicate with each other. Generally there is a central computer (SYSOP) which acts as a clearing house or message center. Users call this computer and leave or receive messages. It is useful in getting responses for questions, technical help, and other information, you may place a request for information on a particular case one night and receive a reply the next morning. CBBS users come from a wide spectrum of society and are generally very helpful, providing a substantial source of information. Questions such as availability of a certain type of ammunition, popularity of a specific drug in a select location, or who saw something unusual on X street at 4 a.m. can be quickly submitted and, in most cases, answered within a few hours. Identifying or locating missing children, bodies, possessions, and so on generally receive excellent responses. Most metropolitian areas have several CBBS which are free. Some law enforcement departments have established their own CBBS (for example, Maricopa County Sheriff's Office Public Access Bulletin Board System) [*8*]. Your local computer stores or most computer magazines can supply you with SYSOP phone numbers or inexpensive software for your own CBBS. There are over 1000 CBBS nationwide.

Several subscription databases (Source, Compuserve, AMA Net) offers CBBS on a nationwide basis. There are many forensic science, medical, and law enforcement people who access these services regularly [*2*].

Word processors are program that help prepare and edit letters, reports, and other typed materials [*9*]. The user need only type the material once, make editing changes, and print a final draft. Changes can be made electronically and a revised copy printed. There is no need for the operator to retype. Multipe copies can be printed at the touch of the computer key. Mail merge capability will allow the user to generate "personalized" letters to large lists of people automatically. Computer spelling and grammar checking programs can examine and correct each draft. The equivalent of 100 to 1000 typed pages can be stored on each floppy disk and transmitted over the telephone. Duplicate floppy disks can be easily made (2 min) and inexpen-

sively mailed. Case inquires, reports, research, personal correspondence, and political mailings can be quickly and inexpensively produced by computer. In the past, dedicated word processors (computer and software) were sold as an expensive package ($15 000 to $30 000). Today you can buy a word processing program disk that allows you to word process and also use your computer for other functions. There are over 800 different word processor programs ranging in price from free to $400.

Other Applications

Graphic software requires the use of a printer or plotter and a digitizer (flat pad with a stylus) to produce drawings, charts, overlays, and graphs, useful for case analysis and courtroom presentation (Fig. 5). Drawings can be enlarged, reduced, shaded, and enhanced in color at the touch of a button. Bite mark and other evidence-matching operations are ideally handled by this type of system. Graphic printers ($250 to $1000), plotters ($1000 to $1500), digitizers ($75 to $750), and TV cameras ($500 to $1000) are available at most computer stores.

Card readers and optical scanners can process large quantities of printed matter automatically. Surveys, data collections, name lists and other "hard copy" can be converted to computer applications easily.

Bar codes and bar code readers ($200 to $600) are useful for inventory, record filing, and evidence tracking (Fig. 8). A bar code is a small series of thick and thin lines (such as, we often see on grocery products) which are identified (read) by a pencil-like bar code reader (wand). Each bar code represents a predetermined collection of data such as case name, file number, record location, and so on which can be rapidly identified and tracked. Often used by libraries, these bar codes can quickly record, identify, and locate material which may be lost with manual systems.

Cautions

As with all good things, there are some potential problems that must be considered when using microcomputers. Knowledge of these difficulties is the best way of avoiding disappointment and embarrassment.

The hardware (equipment) for most computer systems is standardized; however, many

FIG. 8—*Bar code and a portable bar code reader (Compliments of Hewlett-Packard).*

manufacturers will restrict the use of their products with other peripherals. You may not be able to use an Apple computer with a TRS 80 disk drive. The best test of compatibility is to see the computer system that you are considering actually operate, doing all the functions you expect it to do.

Select your software first, then the hardware to run the program. A computer without proper software is useless. See the program operate before you buy.

Be skeptical of what you hear and read. "Vaporware" are products that are advertised but do not exist. Often they are sold to customers and placed on back-order . . . forever. If you cannot see it or watch it operate, it does not exist. The greatest problem in computing today deals with sales promises that exceed the real capabilities of the product delivered. Before you buy, make certain the system works to your specifications.

Your computer is only as good as the data it receives. The rule of GIGO (garbage in, garbage out) applies.

Do not entirely trust computer results. Spot check data and reports. Just as people make mistakes, computer systems can create errors too. These are termed "bugs" or "glitches." One such example is the computer system that writes the $1 000 010 check to pay the $10 bill.

There is a tendency in many bureaucracies to try to make use of old, useless equipment. If your department has an old computer, you may be pressured into using it rather than purchase a new unit. But keep in mind that microcomputers can often be used as extra terminals for larger computer systems. Thus ordering an extra "terminal" for the old computer may be a more politically effective action than ordering a "new" computer.

Select a micro computer that has sufficient memory capacity. A computer that uses less than 1000 records may require a floppy disk drive and 64 KRAM (for example, Apple II, TRS 80 Mod 4) (Fig. 4). A system requiring larger record numbers would benefit from a hard disk and 256-512 KRAM (such as, IBM, PC, HP 150, Corona, Altos) (Fig. 1).

Consistently back up your data. Making extra copies of your data takes only a few minutes but protects you from data loss should an accident befall your data disks. A spilled cup of coffee or magnetic key ring has ruined data on many a floppy disk.

Unless you enjoy the unexpected, avoid developing your own software. Programmers, who are paid hourly, can consume incredible amounts of money with little to show for your investment. Debugging, the testing and perfecting process of software development, can take years and cost thousands of dollars in lost time and effort. If you can, buy a well-tested software package from a dependable vendor. Check references of people who are using the software in your area.

Computer prices vary as much as those of automobiles, and sales are similarly discounted. Few people expect you to pay "sticker price." Competitive, open bidding and vendor negotiating can be financially rewarding provided there are adequate local support and repair services. Since most vendors make their biggest profit on the sale of hardware, software is often neglected and you are pushed to overbuy equipment. Ask, "How will this feature help me?" and "Can I do the operation without this feature?" Get all promises in writing.

Getting Started

A trip to your local computer store can be quite rewarding. Ask questions about hardware and software, and know your own needs. Buy a few computer magazines such as *Byte*, *Personal Computing*, and *Microcomputing*. Look primarily at the advertisements for prices and competitive features. Look through a few computer books at your local library. You learn by doing and a slight knowledge of computer jargon is helpful. Taking computer courses has limited benefit because 90% of course material involves specific hardware and software which you will probably never use. Your dealer will be happy to help train you and your staff as a condition of the sale.

Summary

In recent years there has been a revolution in computer technology where small, inexpensive, and powerful microcomputers can do the work originally done with large, expensive minicomputers. Microcomputers and the new user-definable and communications software now allow the forensic scientist to automate much of his or her work. This saves time and promotes efficiency at a substantial financial savings.

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