Technical note

The hydrological data manager and digitization in 1985: points to ponder in the development of a new digitizing system*

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Abstract

The information which is extracted from digitized autographic rainfall and runoff records is used in a large number of design decisions. In addition these data are invaluable to many hydrological research programmes.

The role of the person who performs the digitizing, the digitizor, is most vital to the success of this aspect of hydrological research. Consequently the system design should centre around the motivational and operational requirements of this person. The recently designed system which is currently in operation in the Department of Agricultural Engineering at the University of Natal is described in order to illustrate these design requirements. The new digitizing system makes full use of the latest hardware and software technology and in so doing allows the digitizor considerable flexibility and control over the process of digitizing.

Introduction

Digitized autographic records have been used in many operational and research programmes in the field of hydrology and hydrometeorology in South Africa. Every year thousands of design decisions, involving many millions of rands, are made by Government departments, engineering consultants and others regarding the construction of bridges, waterways, spillways, dams or conservation works. These decisions in some way or other all utilize rainfall intensities or kinetic energies for critical durations (ranging from less than 5 min to several days) and recurring at selected frequencies. Until fairly recently such information could be derived only from analyses of autographic raingauge and runoff records. There is still a large amount of historical data on charts which have not been digitized. The complete transition to solid state recording will probably take many years. Effective digitizing systems are therefore important for the present and the foreseeable future.

The first published documentation in South Africa on digitizing procedures was that by Johanson (1974; 1975), followed several years later by Schulze and Arnold (1980). Meanwhile digitizing programmes had also been developed or adapted from the above (for example, at the Department of Water Affairs, the Weather Bureau and the Directorate of Forestry). The standard reference used in South Africa on rainfall depth-duration-frequencies (Midgley and Pitman, 1978) utilized manually extracted data from rainfall charts. A series of post-1978 hydrological project reports in South Africa used digitized data, for example, Roberts (1979) in studies on model testing on Eastern Cape data, Schulze (1979; 1980) as well as Schulze and Easter (1979; 1980), Smithen (1981) and Smithen and Schulze (1982) on rainfall kinetic energy research in South Africa, Schmidt (1982) on runoff testing and more recently Schulze (1983; 1984) in first assessments of rainfall depth-duration-frequency and synthetic rainfall distributions in Natal using digitized data.

Kovacs *et al.* (1985) used the digitized data from autographic raingauges, manned jointly by the Natal Parks Board and the Department of Agricultural Engineering, in order to assess the rainfall intensities associated with cyclone Domoina (1984) in the Umfolozi game reserve.

A decade after the commencement, on a serious scale, of the digitizing of historical hydrological data in South Africa, the research community is still way behind in providing themselves with an adequate digitized data base. This data base is, however, needed desperately for more cost-effective hydrological decisions. Meanwhile rapid technological advances have been and are being made in the field of micro-computers. Now therefore, more than ever in the past it is necessary for data managers to adapt constantly to these developments, since their implications are most crucial to the success of digitizing procedures, both in terms of efficiency and accuracy.

Through this paper the authors wish to share their views and experiences which are the result of 10 active years as data managers and developers of several digitization systems. The main features of the recently designed system which is currently in operation in the Department of Agricultural Engineering at the University of Natal will be described in order to illustrate important points. This new digitizing system makes full use of the contemporary hardware and software technology and in so doing enables the digitizor to exercise considerable flexibility and control over the process of digitizing.

Digitizor: computer interaction

The key role of the digitizor is vital to the success of this aspect of hydrological research. Consequently the system design centres around the motivational and operational requirements of this person.

Points to ponder

- Autographic rainfall and runoff charts certainly should, and in all probability will, be digitized only once and never again, for use by the hydrological fraternity in South Africa. It is therefore vital that this task be carried out by alert and motivated persons and that it should not be left to unqualified and unmotivated persons, working with outdated hardware and software.

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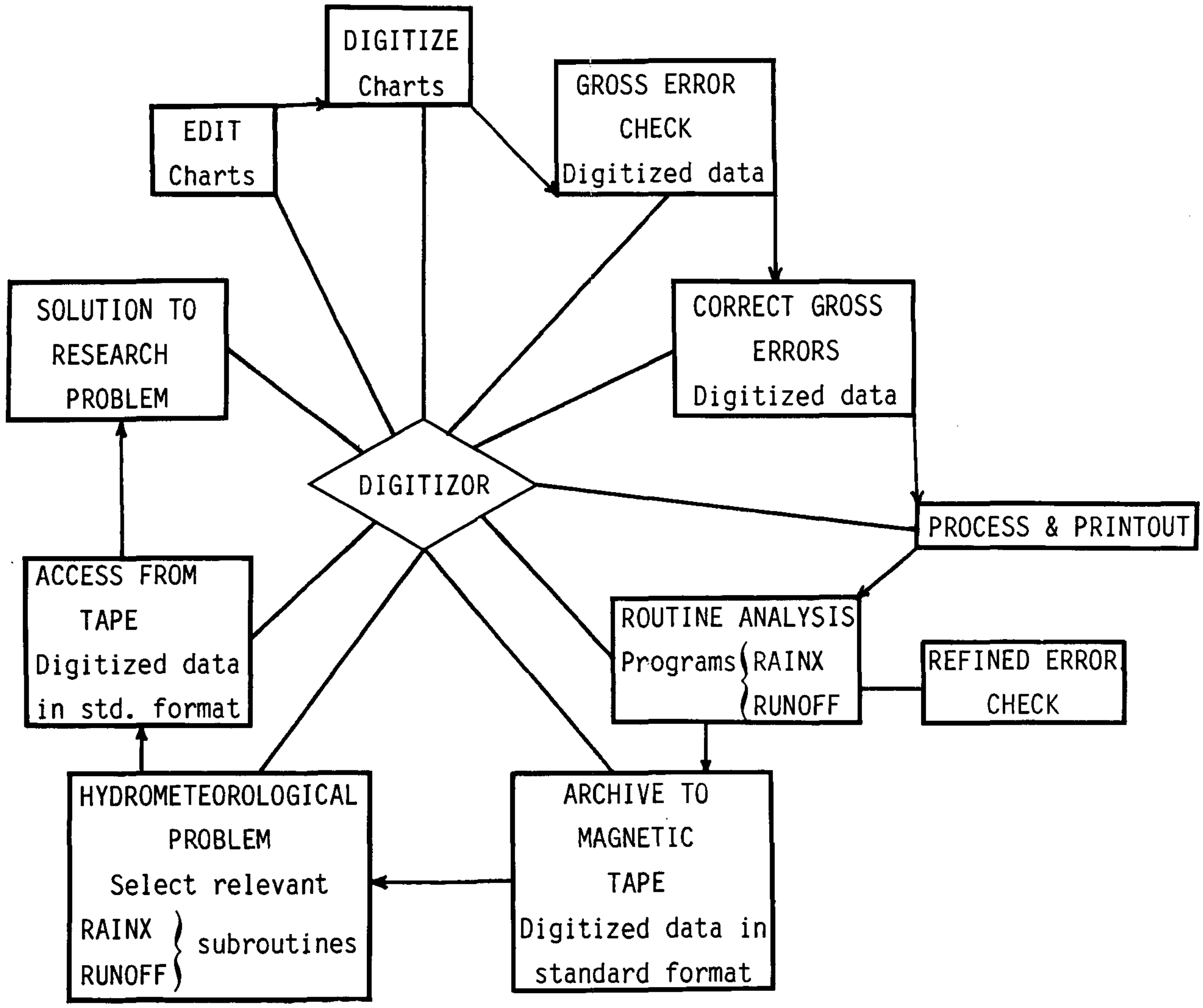

Figure 1
Flowpath of the processing system (after Schulze and Dent, 1982).

*Numbers 1, 2, 3, 4 and 5 within the phase blocks refer to the PHASES.

- Digitizing is a tedious occupation. It has been the authors' experience, and that of other organisations, that this tedium leads to a high staff turnover. Consequently, productivity is reduced.

- Hardware technology now presents data managers with an opportunity to rectify this situation. The opportunity should not be missed by stinting on the most vital area of software which will assist in motivating and interesting the digitizor.

- The authors believe from their experience, (Schulze and Dent, 1982) that high staff turnover is best remedied by involvement of the digitizor in all facets of the operation. Research is necessary to motivate and incorporate the digitizor into the overall hydrological program at a research institution. The key position, held by the digitizor, is aptly illustrated in Figure 1. In order to introduce the new hardware and software to the digitizing personnel, the authors proceeded in the following manner. The digitizors were first instructed on the general use of the computer and shown how to write interactive programs. Within a day these people, who had no previous programming experience, were writing and executing interactive programs. This exercise was considered essential, in order to enable them to formulate their overall approach towards the computer which was to be their tool and companion for many hours of each working day. It is of crucial importance that the digitizor should feel in control of the program and not *vice versa*.

Development of a digitizing system

An increasing number of research efforts are being concentrated through research teams. In today's world the rapid technological change the research team needs all types of people; the innovator, the writer, the computer scientist, the manager, as well as the dedicated, alert and motivated data processor. The most time consuming and hence expensive and often, the most crucial, part of hydrological research or consultation at present is the process of data gathering or data generation. In view of the abovementioned and the experience of the authors, they are led to the conclusion that the research component, in creating the correct conditions for the digitizing work, is considerable. They believe that it is the responsibility of the data manager to become intimately involved in every step of this research and development process in co-operation with the digitizor and the computer software specialists.

One of the main sources of delay and frustration in the Department of Agricultural Engineering's previous digitizing systems was the fact that errors could be made and remain undetected until they caused problems at a later stage in the processing cycle. Inevitably this would require that a section of chart be re-digitized, and the data be re-processed and then inserted into the good data file. Productivity suffered as a consequence. They two key features of the Department's new program are therefore:

- the early detection of errors;
- the simple insertion of sections of re-digitized data into the data file.

Before proceeding with the outline of the new system it is necessary to introduce certain terminology and some of the technical capabilities of the new computer system. The terms chart, trace and frame are used in this paper; these terms are defined as follows:

- chart – the entire strip of paper on which the autographic trace is drawn;
- trace – the line scribed on the chart by the recording pen;
- frame – the section of the chart which is placed on the digitizing board at any one time, this frame being the entire chart in the case of drum type recorders e.g. certain Casella rainfall charts.

The program is designed for a Hewlett Packard 9816S microcomputer. This computer has 256 kilobytes of user available memory and two floppy disc drives. The program follows a menu type format and is structured in subroutines. The screen is cleared after each question and example answers are given in the phrasing of the question. In addition, common conventions and the range of possible answers are presented on the screen when the question is asked. Each answer is checked for validity, if possible, and in the event of an unlikely answer, the program prompts with an error message and re-displays the question. Errors are thus detected as they occur and can be corrected immediately. It is most frustrating and disheartening for the digitizor to encounter an error induced termination of the program, on completion of a lengthy spell of digitizing. A sizeable portion of work then has to be repeated.

The program is written in a friendly and powerful version of the BASIC language which allows variable names of up to 16 characters. The source coding is therefore easy to interpret. In addition this BASIC language has "block if" statements which allows structured programming. The editing is very simple and the digitizing personnel are encouraged to make editorial suggestions for the program. They have already made and implemented numerous innovative improvements to the program in order to make it more user friendly and to cope with the many extraordinary situations which inevitably arise in work of this nature, and which are not foreseen when a program is developed initially.

Figure 2 shows the menu structure of the program. One of these softkey menu's is presented on the softkeys at the bottom of the screen at all times. Each set of softkey menu options connects to the next phase. The inter-phase connection softkeys are shown

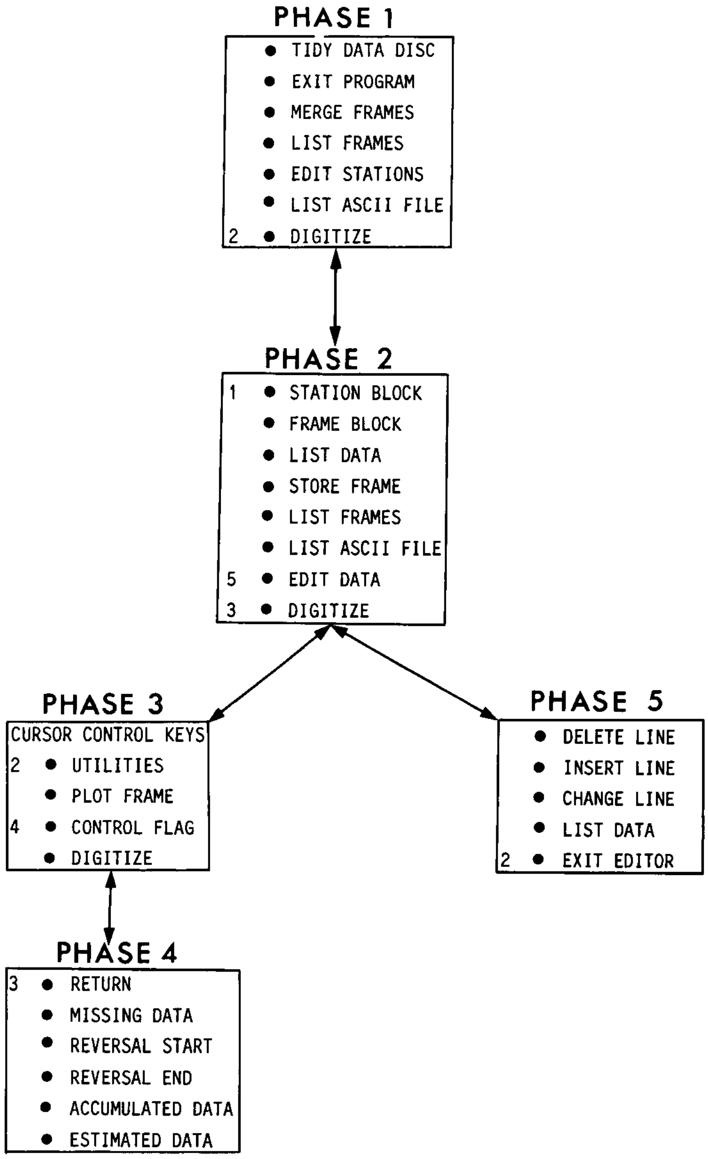

Figure 2
The phases of the menu-structured digitizing program.

in the square to the left of each softkey option. For example, if the softkeys for phase 2 are displayed then softkey "STATION BLOCK" returns the program to phase 1 and softkey "DIGITIZE" returns the program to phase 3. The softkeys which do not move the program onto another phase enable the program to carry out a specific routine e.g. plotting the trace of the current frame. Control is then returned to the same location in the program on completion of the routine. Within each of these routines, defined on the softkeys, there are questions to be answered and menus to be selected from the screen questions.

An explanation of the components of each phase is presented by Dent and Schulze (1985).

Conclusions

Faced with rapid changes in computer technology the data manager must decide whether to develop new custom-written software or to simply make minor changes to an existing system in order to adapt it to the new hardware. The experience of the authors has been that the time and expense invested in the new software system is more than justified by the resulting increase in productivity. Digitizing and subsequent processing in the Department of Agricultural Engineering is proceeding at a rate approximately 5 times faster than that using the software developed in 1979. The cost of the custom-written software was less than half that of a 9816S personal computer. The authors drew up the specifications for this software and also worked on its development. This had the added benefit of extensive study of the capabilities of the new computers. The authors have no doubt that the benefits of this new system have already out-weighed the costs, by orders of magnitude.

The speed and built-in software capabilities of new computer systems, such as graphical display, file handling, file sorting and file concatenation are major new developments. These improvements allow for flexibility, ease of trapping errors at their source and for the reduction of digitizor frustration when using the system. The program contains an interrogation routine which treats "errors" such as negative time steps, digitized points outside the frame and zero depth changes in the appropriate manner.

Notwithstanding the obvious advantages of the above it has been a most educative process, incorporating the benefits of years of experience into the new program. Since the computer memory is very large it has been possible to transfer the experience and conventions to the digitizor at the precise moment that it is required. Anomalous data entries can be checked and corrected as and when they occur. Small yet important procedures become so much part of the digitizor's everyday routine that when the experienced digitizor is called upon to train a new person, many of these essential techniques are not transmitted adequately.

As managers of a digitizing system for 10 years, remarks similar to the following have often been heard:

> "but is this information not recorded anywhere, so that I may read it up and then know all the pitfalls and quirks of this digitizing procedure?"
> or
> "Oh, no! If only I had known that 6 months ago. I have been doing it the wrong way and then correcting it later, at considerable invoncenience to myself".

Although it is possible to include many questions and checks into such a program one should guard against including too many questions. A balance should be struck between asking too many or too few questions. Just sufficient questions should be asked of the digitizor so that the answers provide an independent cross check when compared to answers and deductions from earlier questions.

The ease with which such new instructions may be entered into the program makes this an ongoing and growing process which involves not only the digitizor but also the data manager. Data managers should be responsible for the continuous improvement of the program. They should not fall into the trap of developing the program and then leaving it to accommodate all eventualities. The program should be able to be modified easily in the event of a request by the digitizor. The digitizor should not have to learn to live with an unwieldy, inconvenient, non-informative program. The data manager should be on hand to attempt to solve problems, as and when they occur and should become involved with an earnest desire to solve the problems and streamline the digitizor's task – with promptness!

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