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# Data base navigation: an office environment for the professional

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**Abstract.** The potential of the computer to assist in the everyday information handling activities of professional people has received little attention. This paper proposes a number of novel facilities to produce, for this purpose, an office environment in which a needed item of information can rapidly be sought and identified. It involves a new display technique which overcomes the classical "windowing" problem, and the use of natural dialogues utilizing simple actions such as pointing, gesturing, touching and spoken commands. The simple dialogue makes the scheme well suited to the professional person, who is most likely unwilling to learn complex command languages. Little disturbances to the appearance of the office need be involved.

## 1. Introduction

Professionals, such as lawyers, managers, company presidents and engineers, spend much of their working lives handling information. Items of information are accepted, examined, annotated, filed, shared, copied, assigned priority and eventually destroyed, to name only a few such activities. The potential of the computer and other electronic techniques to assist these information handling activities is immense, but curiously underexploited: few professionals have anything computationally more complex than a pocket calculator within their personal offices.

The slow emergence and acceptance of such computational assistance can be attributed to a number of factors, many of which are associated with human attitudes and behaviour rather than limitations set by technology. For example, constraints are imposed by the lack of enthusiasm of the typical professional to be trained in the use of complex command languages. Another impediment is the sensitivity of professionals to the appearance of their personal office, and particularly to the introduction of a keyboard (Manuel 1981). Also a major difficulty arises from the limitations set by human memory, which is such that a given item of information can often not be specified immediately, uniquely and without error: some preliminary searching or browsing is usually necessary and it is essential that this can be achieved with the most simple of commands.

With information handling it is useful to distinguish between two essentially different tasks. One is the specification of an item of information that is of interest—the other is the retrieval of that item from wherever it may be located. It is the former activity—specification—which is the subject of this paper, and for which we propose a novel scheme having many desirable features. By contrast with information retrieval,

† On sabbatical leave at Imperial College from October 1980 to June 1981.

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which is already the object of intensive research and where efficiency is dictated largely by hardware and software considerations, the human–computer interaction associated with information specification has received little attention.

The novel proposal presented in this paper is expressed in the form of a description of the Office of the Professional. It offers the significant benefit that very little skill is required of the user; only natural actions such as pointing, gesturing, speaking and touching are required. Nor is any radical change in the appearance of the professional's office involved. Furthermore, all components of the proposed scheme lie well within the capability of available technology, and the scheme is attractive from an economic point of view.

## 2. The office of the professional

Certain general characteristics of professional people have already been mentioned in order to demonstrate the problems that must be resolved if computers are to be used to simplify their information handling activities. These characteristics include a reluctance to be trained in the use of complex command languages, a dislike of keyboards and sensitivity to the appearance of their working environment, henceforth referred to as the 'Office of the Professional'. In addition, professional people frequently participate in discussions, are generally supported by a secretary, and may need to have access to an extremely large store of information.

The direct needs of these people just described are not entirely satisfied by the concepts and techniques normally associated with the term 'Office of the Future'. Considerable attention, supported by massive investment, has been directed towards this area. However, as popularly represented, such an environment is tailored rather to the needs of support staff having characteristics and job specifications very different from those of the professional. Secretaries or clerks can be given extensive training in such skills as typing and the operation of word processors; they are generally not required to have access to as much information as professionals, but they are often trained in, and adept at, the highly efficient organization of information. The information handled by such people is usually more structured and formal than that associated with the work of the professional.

In this paper, exclusive consideration is given to the information handling activities of the professional person. It is important to note, however, that many of the concepts and innovations described are equally relevant to other information handling activities, such as civil and military command and control and library search.

## 3. Information

The commodity most crucial to the activity of professionals, and which permeates their working environment, is information. While this commodity is often embodied in printed text, it can also include recorded speech and printed or projected pictures and diagrams. Individual items of information may vary in their extent, from a scribbled note to a lengthy legal document, and, as mentioned earlier, many different actions may be performed on a single item of information.

However, it is usually the sheer volume of information relevant to the professional's task that underlies the need for computer assistance. For this reason, in order to lay a basis for our scheme, it is convenient to select an illustrative example which will provide some understanding of the problem, introduce some of the concepts and establish necessary terminology.

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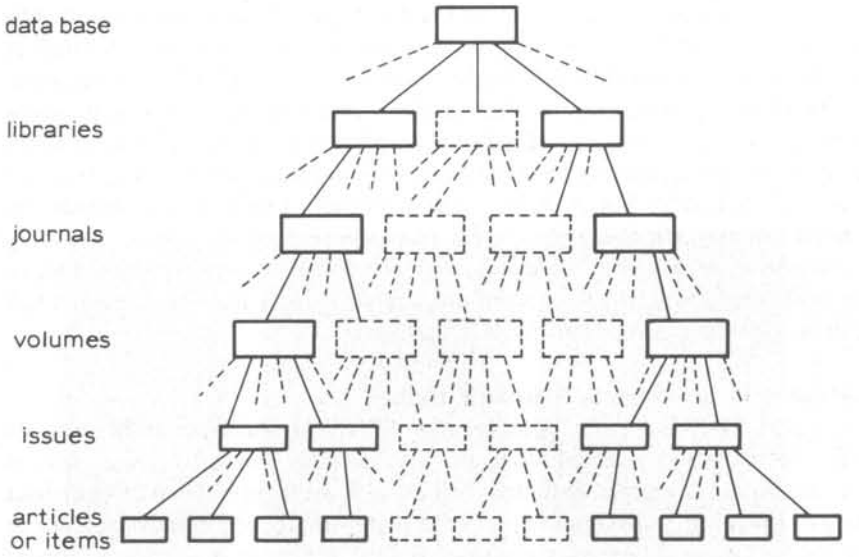



Figure 1. The terminology used to hierarchically classify the professional's data-base.

Assume that the information accessible to the professional is subdivided hierarchically into *libraries*, *journals*, *volumes*, *issues* and finally *articles* or *items*, as shown in figure 1. With a multiplication of ten at each level in the hierarchy, about $10^5$ items might be involved, each of which may itself comprise several pages of text. The terminology used here is familiar for the example of a conventional scientific journal, with a total run of 20 years necessarily containing 20 volumes, hence 240 issues, and perhaps 5000 articles. For convenience, the same terminology is used in other contexts, as for example the professional's in-tray, which might also be classified as a journal. The contents of this in-tray, ranging from personal reminders and messages from colleagues to incomplete drafts of papers, will vary considerably from day to day.

From these examples it can be appreciated that the professional may require access to upwards of $10^6$ conventional printed pages.

## 4. Location by visual scan

In order to retrieve an item of information in a conventional office, one must first locate, within the library (comprising perhaps a conventional library and/or collection of files in cabinets), the necessary book or file containing the item. In doing so, one most certainly relies upon memory of where the book was last located, as well as spatial and other clues ('behind the red book to the left on the top shelf') and symbolic or textual labels (e.g. book titles or coloured stickers) (Bolt 1979). This memory will be considerably enhanced if the available books can be *seen*, for it is then necessary only to follow the recall of the approximate location of a needed book by a rapid browsing or scanning action in order to locate it. If memory fails, a visual scan requiring not more than a few seconds will usually serve to find the book. Where books are visible throughout the working day, memory will be continually enhanced, albeit unconsciously, by constant awareness of their location.

As they have been developed to such a high degree of efficiency in the human being, spatial memory and search by visual scan should be exploited if possible in the Office of

the Professional. For this reason, each journal in the proposed scheme is represented by an *icon* in full veiw of the user (i.e. the professional), and normally and conveniently affixed to the wall of the office. The icon might consist of a simple piece of coloured card, perhaps with a motif or label to assist identification, about the size of a large postcard (figure 2). Shape and colour can be utilized to aid rapid identification. Alternatively, for appearance's sake, and according to the taste of the individual, icons may appear like book spines. More bizarre but perfectly valid examples of icons would include the Picasso print hanging on the wall, or the plant decorating the alcove; the only requirement is that the icons be visible and fixed. For convenience, in later sections we shall refer to the surface on which the icons are located as the *wall*; in most cases it will be coincident with the conventional wall of the office.

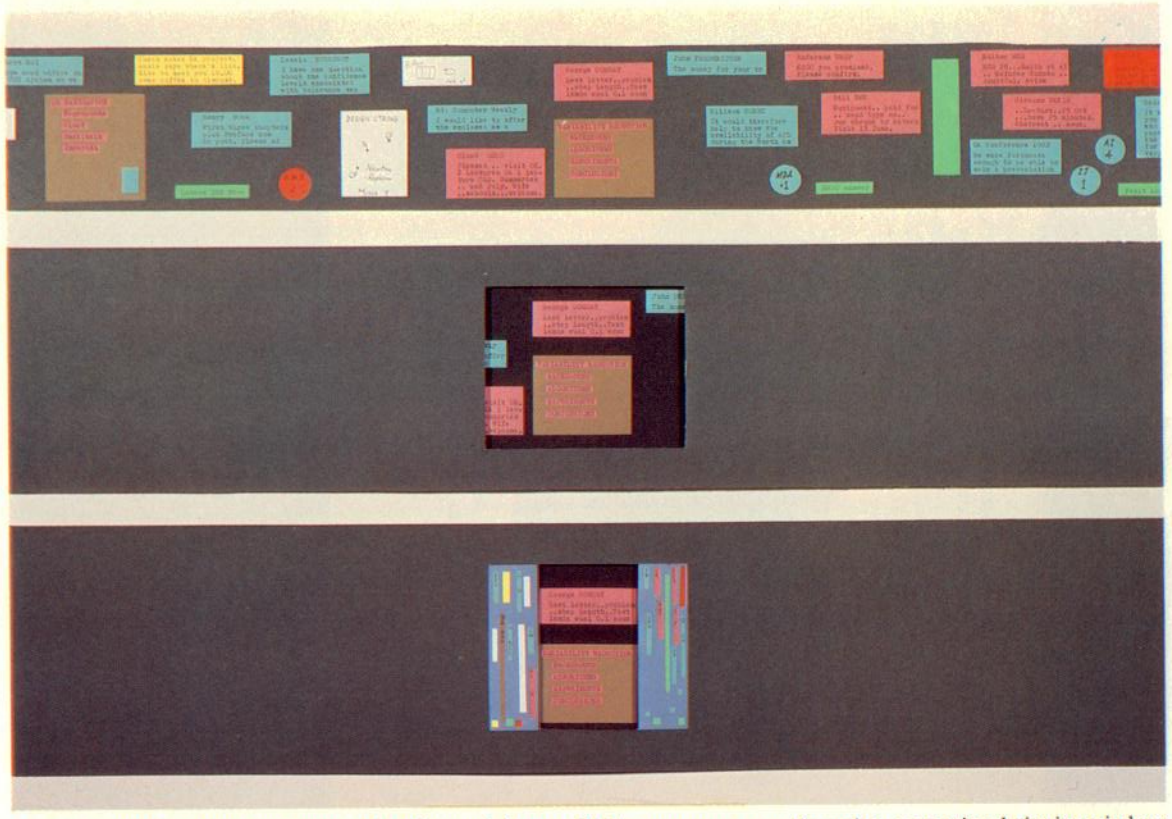
**5. Identification by pointing: the 'teletouch' facility**

The required journal having been located by visual search, it must now be specifically identified and selected. Just as the ability to locate by visual scan is instinctive and highly developed in human beings, so is the identification of an artifact by pointing or touching. It is therefore proposed that journals, represented by icons as described above, be identified by a pointing action. Touching may at first appear preferable; however, to require all icons to be within arm's length might not only be inconvenient, but would also neglect the advantage, to human memory, of having the icons collectively occupying a wide field of view.

The location on the wall to which the user is pointing must clearly be sensed by some mechanism. As pointing is not an exact indication, the location sensed may not be precisely that which is intended, so confirmatory feedback (an illuminated spot on the wall) is essential in order that corrective action can be taken. There is much to be gained economically, as well as in flexibility, if the wall and associated icons are passive, the icons being constructed from inexpensive materials of the user's choice. Ideally, the user should not be required to wear any special equipment. If this requirement is not feasible, any encumbrance should be minimal; the equipment must obviously be light, unobtrosive and comfortable to wear.

These requirements can be adequately satisfied using presently available technology. The use of an electromagnetic sensing device on the user's arm, for example, has been demonstrated for this very application (Bolt 1980), but other effects (ultrasonic, capacitive, infra-red, etc.) offer a variety of alternative approaches. Indeed, the realization of a pointing-direction sensor is considerably eased by the comparatively low accuracy which can be tolerated (approximately $\pm 2°$) (E. Platt 1981, personal communication) given that confirmatory feedback (the "finger-print") allows errors to be corrected by a small movement of the hand. Similarly, a relatively simple mechanism, probably located on the office ceiling, will suffice to provide this 'fingerprint' by illuminating the wall position inferred from the pointing-position sensor. Many acceptable trade-offs within this scheme are possible. For example, although resulting in a less direct pointing action, the use of a touch-sensitive tablet, located on the desk surface, to manipulate the 'fingerprint' position, is an inexpensive alternative requiring no special attachments to be worn by the user. In certain situations, where very few journals are required, the icons themselves can of course be located on the desk.

As the identification of an icon essentially involves the action of touching, though at a distance, we refer to this means of icon identification as 'Teletouch', and the confirmatory illumination as the 'fingerprint' (figure 3).



(*a*)

(*b*)

(*c*)

Figure 5. (*a*) The data space representing the user's in-tray; (*b*) the same space seen through a conventional viewing window; (*c*) the original data space seen through a 'bifocal' viewing system.

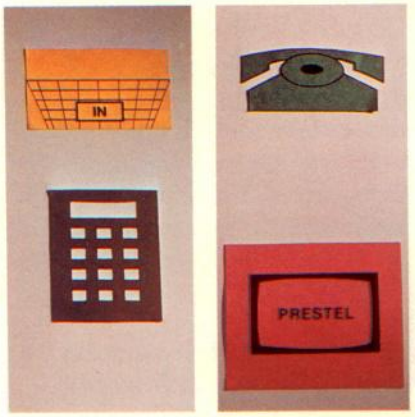



Figure 2. Some examples of icons located on the wall, denoting (upper left) the user's in-tray, (lower left) a calculator facility, (upper right) a personal telephone directory and (lower right) access to the PRESTEL data-base.

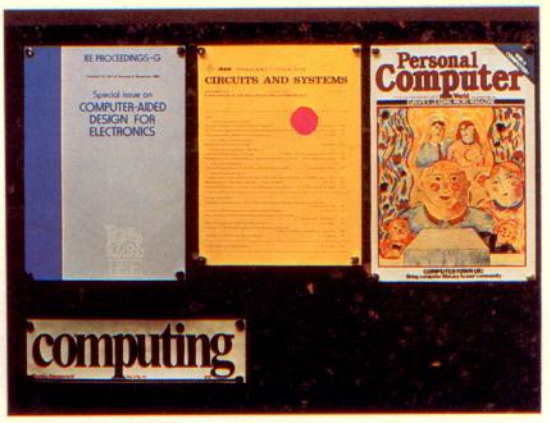



Figure 3. Icons representing journals in the user's library, showing the 'fingerprint' on the *I.E.E.E. Transactions on Circuits and Systems* journal.

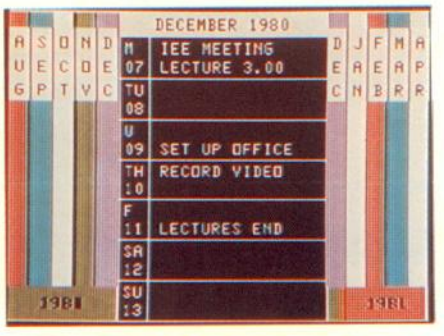



Figure 6. The user's diary as it appears on the Bifocal Display, with the current week in the central region.

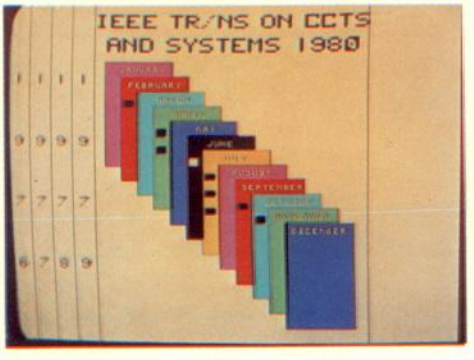



Figure 8. The initial Bifocal representation of the *I.E.E.E. Transactions on Circuits and Systems* journal.

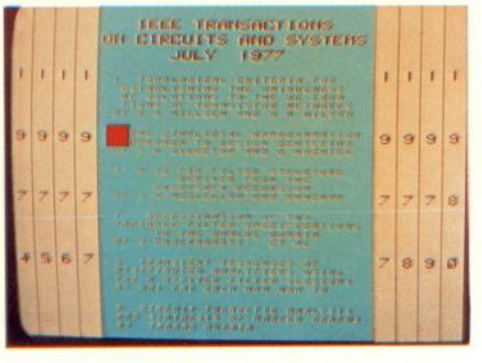



Figure 9. Zooming in on one issue of the *Transactions* causes the displaced months to be represented in the outer regions (1977 on either side of the centre).

In the preceding discussion, the actions involved in locating, identifying and selecting a journal of interest have been described. It is suggested that these actions are entirely natural to the human being, involve negligible or no training and that the maximum time that need typically elapse between the realization that a specific journal is needed and the subsequent selection of that journal is about 2 s. The importance of the user's constant but unconscious awareness of the icons located on the wall should not be underestimated.

## 6. Selection of the journal

Some action must now be taken to confirm that the icon to which the user is presently pointing is indeed the intended one, and that it is the associated journal that is of interest. As the eyes and one arm are fully occupied with the pointing action, this confirmation should preferably not involve any overt motor action on the part of the user; it is proposed that spoken-word recognition be employed. The recognition of isolated utterances in a single speaker environment has been extensively studied and applied (Bolt 1980), and presents few problems in terms of present-day technology (see, for example, VRM 1980)†. Although the successful recognition of a spoken command (e.g. "here") will usually be followed (see § 9) by the presentation of a new image on the desk display, it is suggested that an echo, in the form of a character display of the recognized word, be provided within an unobtrusive fixture on the desk (figure 4).

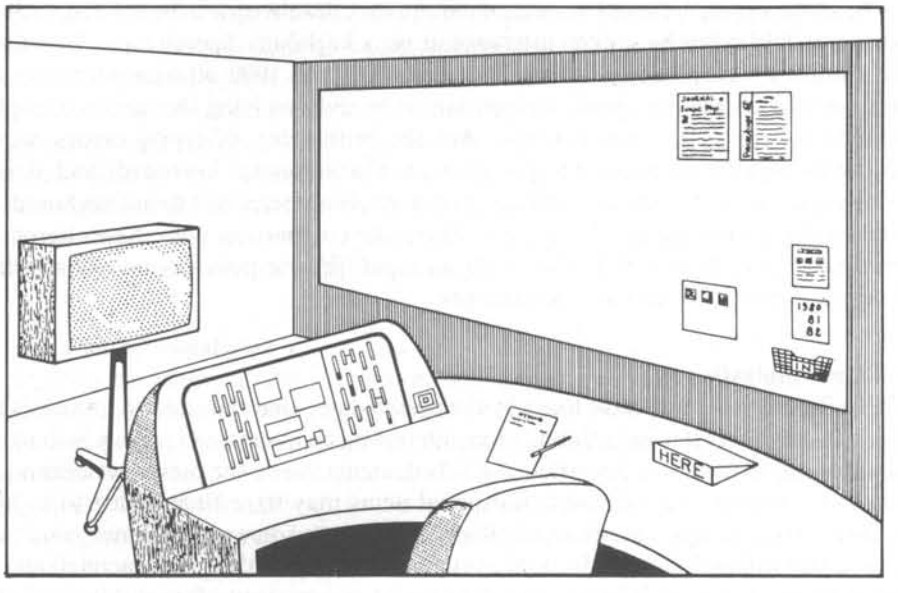



Figure 4. A general view of the office showing the public display (left), examples of icons on the wall (right), and the desk (front) containing the Bifocal Display, a writing tablet, and the voice response display (showing "HERE").

† A recently described system (Peckham 1981) claims to be able to recognize keywords within general conversation.

## 7. Extending the library of icons

Typically, because of limitations imposed by available office wall-space, and aesthetic or other reasons (e.g. poor eyesight), only 100–200 individual icons can be accommodated. This apparent limitation can be overcome by reserving part of the wall space as a dynamic icon area. This acts as a screen on to which can be projected one of a number of slides, each of which is an image of a collection or library of icons. Any of these icons can be selected in the manner already described. This library extension is provided quite simply by a computer-controlled slide projector. The index to the slides is a set of icons located in the permanent icon area, although this facility could be extended by using some of the slides as indexes to others, and is restricted only by the capacity of the projector cartridge.

## 8. Alternative selection procedures

It might be said of the Teletouch journal selection procedure (and of some of the other procedures yet to be described), that the operation could be more simply carried out if the user entered a code directly identifying the required journal. However, the motivating principles behind the Teletouch scheme must not be forgotten. This system requires no remembering of journal titles or codes, or conjuring up of appropriate keywords: the index is ever-present, with journals as familiar and as clearly identifiable as objects on one's desk. Alternatives would require the user to memorize codes or titles for up to 1000 journals, an unacceptable and, as has been shown, unnecessary burden. Consulting an index (requiring frequent updating) or a secretary are clearly unsuitable solutions, and implicitly neglect the potential offered by the computer.

In addition, such alternatives would require the relevant code to be entered, without error, possibly either by spoken utterance or via a keyboard. Speech input for journal identification would require a large vocabulary (up to 1000 utterances), taxing the performance of existing speech recognition units and involving the user in a lengthy training session. The time involved, and the probability of typing errors, would constitute significant disadvantages with an alphanumeric keyboard, and it is a recognized fact that many present-day professionals are reluctant to use keyboards or even to allow them to be seen on their desks. By comparison with these alternative approaches, the Teletouch facility, with its rapid 'browse-point-command' selection procedure, offers considerable advantages.

## 9. Data context

To illustrate the next task faced by the user, assume that the selected journal is the user's in-tray. This journal exhibits some interesting characteristics; at any instant, for example, the user will be uncertain as to its contents. Since the previous occasion on which this journal was accessed, additional items may have been added to it, by a secretary, by colleagues or automatically in response to some pre-ordained condition. Like a conventional in-tray, the data contained in it is essentially unstructured and, in this electronic form, the information can be in one, or a mixture, of many different forms including text, diagrams or pictures and possibly speech. Unlike archival material (e.g. a published scientific paper), an item within the in-tray may invite or even demand a response. These characteristics of the in-tray demonstrate the difficulty of conveniently examining its contents using conventional techniques.

The fundamental question is, "How can the user quickly become aware of the nature of the entire contents of the in-tray, and rapidly examine any individual item in

detail?" To illustrate our solution to this problem, consider the in-tray to be represented by a number of conventional textual messages fixed to a long strip of paper (figure 5 (*a*)). A typical in-tray might contain say 20–50 such items. If a sampled message were to be presented in sufficient detail to allow it to be read then, at this level of detail, only three or four messages could be displayed simultaneously on a conventional VDU screen. Thus, if the conventional "windowing" approach to the examination of the in-tray is employed, all except three or four items will necessarily be masked (figure 5 (*b*)). This effect constitutes a serious problem: at a glance, the user has no idea of the extent or nature of the data contained in the in-tray; how many messages there are, whether any are urgent, or whether an expected message is present. The difficulty has much in common with that of trying to peruse a newspaper through a 2-column-inch sized keyhole ('How long is this article?', 'Where is the crossword?', 'What other headlines are there?', 'What page is this?'), or of attempting to locate a needed diagram or equation within a microfiched article.

A solution to this problem is to *focus* on the area of interest rather than use a window. This approach (figure 5 (*c*)), by dividing the VDU screen into three separate viewports, achieves two key objectives. First, it permits two or three items to be displayed in the central region with sufficient detail to be read in full. Second, at the same time the two outer 'demagnified' regions retain adequate detail of the entire remaining contents of the in-tray, in the form of colour, shape, tags, initial letters, etc., to indicate important attributes such as number, size, urgency, nature and origin of the individual items. Interaction with this 'bifocal' display, which is conveniently housed on the user's desk, is carried out using a touch-screen. The user is able to scroll the in-tray contents through the viewports by simply touching an item of interest in one of the outer regions and 'pulling' it into the central 'close-up' region for more detailed examination. By this action the whole strip of data representing the in-tray is moved across the screen†, preserving the spatial relationships between individual items, and retaining the overall view of the entire in-tray contents. Such a display can be implemented with available technology (Apperley and Spence 1981).

Certain aspects of the principle of this Bifocal Display deserve further comment. The effectiveness of the representations displayed in the outer 'demagnified' regions can be enhanced in a number of ways. In an initial search or browsing operation, humans usually perceive graphic representations more effectively than text. For this reason, and because of the effectively reduced resolution resulting from the horizontal contraction, attributes suitable for encoding items in the outer regions include colour, shape, size, tags, pulsed illumination and position. The use of alphanumerics will be restricted to possibly only a single character per item. A related consideration is distraction caused by detail irrelevant to the level of information search currently being conducted (Morse 1979). Thus, in most if not all cases, the representation of an item in the outer regions of the display should *not* merely be a demagnified version of its central region representation, but a representation more appropriate to the lower resolution of these regions (figure 5 (*c*)). A concept highly relevant to, and illustrative of, this technique of devising appropriate levels of detail, is that which Negroponte has termed "billboarding" (N. Negroponte 1979, personal communication)‡.

† Without wrap-around, although this technique might be relevant to certain activities.

‡ Negroponte shows two slides. One is a conventional view of a city street bordered by buildings having a variety of shapes and decorations. The other shows the same street, but with a box placed snugly around each building, each box being a different colour.

**10. Movement of data through the bifocal display**

The horizontal scrolling movement which appears to be suited to the in-tray example may not be appropriate for other journals. For example, with the user's personal diary, two scrolling modes are suggested. Suppose that when the diary icon is selected, the Bifocal Display shows the current week in the central region, with the rest of the current month, together with the adjacent months, in the outer regions (figure 6). As time is essentially infinite in its extent, it seems reasonable to display only a 12-month period within the three viewports of the display: as this portion is scrolled horizontally through the display, further months will appear on one side as others disappear from the opposite side. When browsing or searching through the immediate past or future with this display, it is convenient to undertake a vertical scroll, stepping through individual days with a window of 7 contiguous days. For a rapid jump of more than a few days, the most appropriate movement is a horizontal one, achieved by 'pulling' the desired period into the central region as previously described. Thus in the central region the diary can be considered to be a two-dimensional arrangement of 'pages' (figure 7), each representing 1 week, which can be scrolled through the central viewport both vertically (by days) and horizontally (by weeks) such that at a given time any 7 contiguous days can be seen in detail. If vertical scrolling leaves Tuesday at the top and Monday at the bottom, then subsequent horizontal scrolling will preserve this relationship.

It could easily be arranged for a flick of the finger (i.e. a rapid application-move-removal of the finger) to initiate a continuous movement of the volume through the central region of the display, such motion being terminated either by touching the display, or automatically when the edge of the volume reaches the edge of the central region.

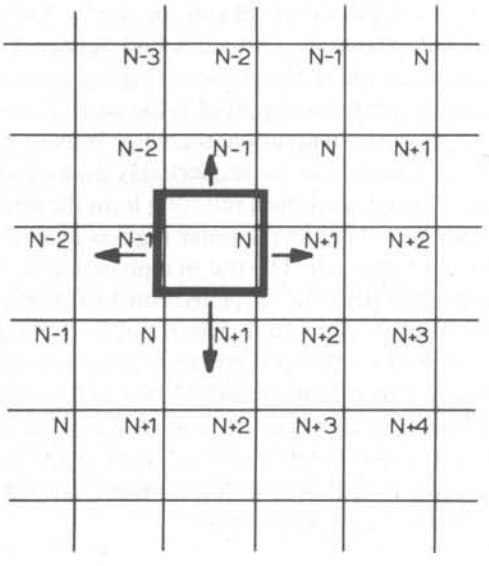



Figure 7. The conceptual two-dimensional arrangement of the diary pages, allowing horizontal scrolling of weeks and vertical scrolling of days.

## 11. Information levels

In order to describe additional beneficial attributes of the Bifocal Display, and at the same time provide a basis for estimating the amount of information that can be accessed within a library of reasonable size, it is useful to introduce the concept of *information levels*. Consider a different journal for illustration, for example the *I.E.E.E. Transactions on Circuits and Systems*. The wall constitutes the first level of information, where we locate and specify a simple icon (say the cover of a representative issue of this *Transaction*, see figure 3). The resulting image on the Bifocal Display might appear as shown in figure 8: the (annual) volumes displayed in the outer regions constitute the second level of information, whereas the individual monthly issues represented in the central region are at the third level. In this example, each monthly index (not yet shown) has been annotated by the user to provide iconic clues to items of special interest: at this level (level 3) these annotations take the form of coloured tags and the initial letters of the author's name.

For most items of interest, with exceptions such as short messages within an in-tray, the detail provided at information level 3 is insufficient. To obtain further detail, and still retain the advantages of the Bifocal Display, a 'zoom' action is carried out within the central region. First, a 'fingerprint' is placed upon the level 3 representation, in the central region, of the item of interest (the July issue, for example): it is assumed that a 'fingerprint' will always appear at the most recently touched position on the screen. Touching a 'zoom' control causes the fingerprinted item to increase in size until it fills the entire central region, at which time its image is replaced by a more detailed one, the information level 4 image which is more appropriate at this higher resolution. The displaced level 3 items from the central region are kept in view by slightly displacing the data in the outer regions to accommodate their level 2 images (figure 9).

For the in-tray, this level 4 representation would be adequate to enable most messages to be read. With the scientific periodical however, some vertical scrolling may be necessary in order to view the entire contents page of the monthly issue selected. The central region of the display will revert to level 3 when either an item in one of the outer regions is 'pulled' towards the centre, or the zoom is cancelled by touching the bistable zoom control a second time.

With the scientific periodicals, information level 4 still does not provide sufficient detail to enable an item (i.e an individual article) to be read. To obtain the required detail, which is contained in the information level 5 representation, a choice between two alternatives is suggested. First, a transition of the central region of the Bifocal Display to level 5 could be arranged in much the same manner as the transition from level 3 to level 4. Although such a hierarchical descent through a data space can result in one losing one's sense of location within the space, it must be remembered that, with the Bifocal Display, the entire data space remains visible within the information level 2 image in the outer regions of the display, so avoiding this problem. Alternatively, the need to be able to present information to colleagues gathered for discussion suggests the value of a 'public display', located within the office (figure 4), on which the level 5 image could be displayed.

As with the transition to level 4, the display of the level 5 representation of an item is initiated by fingerprinting the required item in the level 4 representation, and then touching the appropriate control. With the scientific periodical, a fingerprint would be placed on the title of an article in the issue's contents page displayed as the level 4 representation. The subsequent zoom or display action would lead to the display of the

first page of the article. Movement through the article can be achieved by a page-turning action (e.g. using a joy-pad (Bolt 1980)) or by a vertical scrolling action. It is interesting to note that, with future publications, the concept of a page, imposed by the use of books and book-like binding of paper, may be lost. Certainly, scrolling has the advantage of retaining the maximum context around the area of interest.

The accessing of individual *items* at information level 5, within each *journal* appearing at level 1, is thus achieved by a three-level index comprising information levels 2, 3 and 4. At least 10 choices can be provided at each of these levels, allowing for more than 1000 items per journal.

## 12. Comment

The proposed scheme raises many questions which require a great deal of consideration, and which are not treated in this paper. We therefore comment briefly below on certain aspects of the scheme worthy of mention.

### 12.1. *Other information-handling activities*

Examples have been quoted of the many ways in which a professional handles information but, for the proposed scheme, details have been given only of the process of specifying the item required in a search procedure. The manner in which other activities such as journal creation, transmission of items, annotation, etc. might be achieved within the same system has been proposed, and to a limited extent evaluated, and some of these activities demonstrated in a videotape simulation of the system (Apperley and Spence 1980). However, further detailed study and evaluation of these activities is needed.

### 12.2. *Applications*

The paper basically describes a philosophy of human–computer interaction, and illustrates this philosophy in the important context of the Office of the Professional. The same philosophy would appear to offer considerable potential in other contexts, such as library search, civil and military command and control and in public and private viewdata systems.

### 12.3. *Data-bases*

The task of retrieving an item of information once it is specified has intentionally been ignored in this paper, as retrieval is a problem common to all information handling systems. Nevertheless, the manner in which specification is carried out may well influence the design of the data-base, as the previous discussion of information levels suggests (§ 11).

### 12.4. *Work profiles*

The final detailed form and extent of a scheme such as the one described will be strongly influenced by the nature of the professional's work, so that a necessary component in the gradual evolution and adoption of such schemes will be studies of typical work profiles. To be effective, such studies must do more than merely calculate the amount of text currently stored in an office: the location and nature of data-bases and the extent to which a person's information is shared with others, are important factors. Some work along these lines has already been carried out (Coulouris 1979).

12.5. *Information capacity*

Using the projected icon library facility (§ 7), the system described can easily provide for access to up to 1000 journals, and more than 1000 items can be accommodated within a single journal (§ 11). Thus, access to more than 1 000 000 items, each of which may itself consist of many pages, is well within the capabilities of the system.

12.6. *Technology*

Despite the claim (see also below) that the proposed scheme places no severe demands on available technology, certain clearly desirable improvements can be identified. Principal among these is a high definition but inexpensive display for the perusal of documents and images, although to some extent the format adopted for future documents may be influenced by available display technology.

12.7. *Human behaviour*

The formulation of the proposed scheme has illustrated the need to be wary of mimicking current conventional procedures. For example, unlike other workers (Kay 1977, Page and Walsby 1979), we do not attempt to reproduce the appearance of a conventional desk-top. Present-day procedures are constrained by available technology and past organizational decisions, and should not be retained if new technology offers better performance using alternative procedures. What *should* be mimicked and exploited are the highly developed and therefore instinctive human perceptual, cognitive and motor abilities that are at present constrained to operate within different technological and other limits.

12.8. *Claims*

Acknowledging the considerable amount of research and development that still remains to be carried out, we list the following key advantages for the proposed scheme:

(1) Very little specialized skill is demanded of the user. Only pointing, touching, gesturing and voiced commands are required. For annotation or short messages, hand printed character recognizers are readily available (Micropad 1979).

(2) The representation of journals by icons on a wall provides an inexpensive, extensive and flexible first-level of information, and permits extremely simple location and specification of a needed journal. Because of the ever-present nature of these icons, the user unconsciously becomes very familiar with their location and spatial interrelationships. Further, the icon capacity of the wall can be considerably extended if the technique of the projected icon library (§ 7) is exploited.

(3) The Bifocal Display presents a solution to the difficult problem of the blinkering effect of windowing, by providing an awareness, at a useful level of detail, of the entire context of an item of information while simultaneously providing a detailed view of that item.

(4) Apart from the obvious presence of the bifocal display on the desk surface, no radical change in the appearance of the office need be involved.

(5) As has been demonstrated in this paper, the scheme can provide access to relatively large volumes of information.

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