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An interactive computer graphical display program has been developed as an aid to user visualization and manipulation of hierarchically-structured data systems such as thesauri. In the present configuration, a thesaurus term and its primary and secondary conceptual neighbors are presented to the user in tree graph form on a CRT; the user then designates, via light pen or keyboard, any of the neighbors as the next term of interest and receives a new display centered on this term. By successive specification of broader, narrower, and related terms, the user can course rapidly through the thesaurus space and refine his search file. At any stage, he deals with a term-centered, conceptually meaningful picture of a localized portion of the thesaurus, and is freed from the artificial difficulties of handling the traditional alphabetized thesaurus. Intentional limitation of the associative range of each display frame, and the use of color, case and interconnecting vectors to encode relationships among terms, enhance interpretability of the display. Facile movement through the term space, provided by interactive computation, allows the display to remain simple, and is an essential element of the system.

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There have been several past attempts to develop a graphical representation for use in visualizing thesaurus and other hierarchical data relationships. In 1965, Rolling [1] described several representations being used experimentally in the development of the Euratom Thesaurus. By 1967, he was able to publish a fairly elaborate set of terminology charts that had been used to subdivide and organize the thesaurus as it developed [2]. In fact, it is not quite accurate to characterize Rolling's terminology charts as thesaurus graphics: they related the major intellectual facets of a field independent of the explicit terms included in the thesaurus. In this sense, the charts were concerned with categorization rather than explicit terminology. Given the complexity already evident at this major field level, one can readily understand that, given the primarily manual techniques available at the time, more explicit treatment would have presented an insurmountable task.

In more recent work, Unesco's SPINES Thesaurus [3] also utilized a graphic representation as a user guide, once again with the object of illustrating major field and subfield interrelationships rather than the relationships among explicit terminology. As with Rolling's charts, the presentation medium was print, and more explicit treatment would have been impractical.

Our work is aimed at development of an interactive graphical thesaurus subroutine package as a user convenience enhancement for searching the Dept. of Energy's Energy Data Base on the DOE/RECON online retrieval system. The EDB thesaurus structure [4] is typical of controlled vocabularies for databases in similar information systems and it is reasonable, therefore, to expect our modularly developed programs to be generally useful. By utilizing computer displays rather than print as the presentation medium, we have been able to obviate the detail versus volume constraint that has limited past efforts. Similarly, computer graphics has allowed us to avoid the temptation to reduce the page count (at the expense of clarity) by increasing the information density on each page. Where printed efforts have displayed a hundred or more terms per page, with elaborate representation schemes placing considerable learning burden on the user, we have taken advantage of the great ease with which the computer can 'flip frames', and have thus substituted facile motion through a multitude of extremely simple frames for torturous navigation among a few rather complex frames.

FUNCTIONAL CHARACTERISTICS

The basis of the display program is a thesaurus 'paragraph', i.e.

a term group composed of a primary descriptor (main term (MT)) and its relations. In present form, our system displays hierarchical (broader term (BT) and narrower term (NT)) and associative (related term (RT)) relations only, since these are the most appropriate to navigation through the thesaurus space. Completeness suggests addition of the other common thesaurus relations (SEE ALSO, USED FOR and USE) as well as 'scope notes' and 'definitions', and these will most likely be added in the future.

Figure 1 shows a typical thesaurus paragraph represented in the traditional tabular form and in tree form on our color monitor. In our representation, the main term appears at center screen and is connected by vectors to its nearest hierarchical and associative relations (BT1, NT1, RT). Secondary neighbors (BT2, NT2) are linked to the nearest neighbors, and, within the five levels depicted, parenting and neighbor links are readily apparent.

Depth in the hierarchy increases from left to right, a concession to the character representation of common computer terminals. (It would have been more natural to increase depth downwards, and indeed we considered this first, but ultimately we rotated the display sideways in order to fit a convenient number of terms on the screen.

Color, case, and character size, keyed to relation type and distance, are utilized to facilitate visualization of term relationships. The specific display enhancements used are not critical, and other commonly available display enhancements (such as inverse video or half intensity) would be just as appropriate. It is useful, though, to provide some form of consistent visual cues to the user, so that his segmentation of successive display frames into components does not interfere with his perspective of the thesaurus.

In Figures 2 and 3, the effects of successive refinement of the search are shown. In Figure 2, the user has selected one of the NT2 terms of Figure 1 as a candidate search term; the display shows him the thesaurus neighborhood from this term's perspective and allows him easily to assess whether this more specific term captures his intent better than its broader neighbor. In Figure 3, a sibling of the Figure 2 term is expanded.

Movements of the focal point through a thesaurus neighborhood are extremely simple for the user: he need merely designate the next term to be displayed either by typing it into the terminal's keyboard, or, with more advanced terminals, by aiming a light pen at the screen position at which it is currently displayed. Focal point movements are unrestricted to the user: he can move higher or lower in the hierarchy or to any related term with equal ease, skipping intervening levels as desired. He can move, in fact, to any point in the thesaurus in a single step, although for movements beyond the current screen bounds, he must obviously use the keyboard rather than the light pen, and must know a specific term to which to transfer. Once in the new neighborhood, he can once again make use of the light pen for local movements. By contrast to the ease of movement provided in the computer graphic display's direct associative link representation, the user of a tabular alphabetic representation (whether computer accessed or manual) must transform his internal concepts of his search space to fit the alphabetic domain of the thesaurus. In most cases, the search term refinement process is, for him, a laborious sequence of page flips through a document the size of a phone book.

The display representations are uniform in all three figures, but, as the focal point shifts deeper in the thesaurus, several thesaurus characteristics become immediately visible. First, it is evident that the RT groups vary radically, even among MT's that are hierarchical neighbors; this is a direct result of the manner in which thesauri are constructed, since representation of unstructured RT's beyond one neighbor link distance would result in a proliferation that would rapidly swamp printed thesauri. (Thesauri intended solely for computer access obviate this problem, since the same methods we have used to limit BT and NT distances can be used for RT's; however, since we are concerned in this paper with a display for existing thesauri, we mention the possibility of enhanced thesauri only in passing.) Thus RT groups visible from one MT are blind for even its nearest neighbors, and motion through the thesaurus neighborhood is essential if the user is to obtain an accurate usage picture. In the traditional tabular thesaurus, the page flipping involved in neighborhood exploration is burdensome and limits the thoroughness with which such avenues are explored.

Secondly, and similarly, descent through the hierarchy exposes parent terms that the user might not otherwise have noted as relevant. While astute indexers might have explicitly specified two parents linked through a common narrower term as RT's to each other, this path might not have been obvious during thesaurus construction, would not have been specified automatically by a term reciprocating program (since it involves a two link chain), or might be overlooked by the user if buried in a long list of RT's. Thus, the user's level of entry into the thesaurus is critical unless he can move his perspective easily through the term neighborhood in which he is interested.

Lastly, from the perspective of the indexer, many common thesaurus anomalies that are difficult to detect in tabular lists become immediately obvious in computer graphic tree displays. We have not included a pictorial example, but typical ones might include multiple paths between two terms, and parallel hierarchical path chains of inconsistent depths among specific terms.

PROGRAM CHARACTERISTICS

The present hierarchical display package, THESGRAF (Thesaurus Graphics), is an interactive program implemented in FORTRAN IV and running in about 20K words in a CDC 6600 environment (but shortly to be implemented for IBM 360/370/3033). It displays hierarchical thesaurus files five levels of depth at a time, accepting tabular alphabetic print files from a term reciprocation program such as LBL's TBLD [5,6]. We specifically elected to use these standard BT, NT, RT formatted files as input to make THESGRAF directly compatible with common existing thesauri. The file format is, therefore, reasonably free of the program and any similar hierarchical file can be displayed. On our present equipment (ISC's Intercolor 8001, an inexpensive color graphic terminal incorporating an internal microprocessor (to generate graphics functions) and a light pen), ASCII characters can be displayed in color or black and white, single or double size, upper or lower case, and THESGRAF will also draw interconnecting vectors among the terms displayed. Minimum terminal requirements for the program include cursor addressability on a C.R.T. with a screen of at least 24 lines x 80 characters.

THESGRAF achieves terminal independence through a personality module: a translation table is used to couple a common internal character representation to the requirements of various terminals. While the ASCII character set is standard on most computer terminals, such features as cursor addressing and vector generation are handled uniquely in each, and desired adaptability to equipment already in place has mandated this modular approach. One table row contains the binary coded character set used for program processing in the host computer, and a parallel row contains the equivalent codes understood by the user's terminal. Character translation is reduced to a subscripting operation, and providing system access to new types of terminals merely involves additional rows.

When a term is input at the keyboard, some character packing and unpacking precedes a search through the thesaurus source file for the target item. In the standalone version of THESGRAF, a binary search algorithm is used to select the target paragraph from a random access TBLD output file. RECON performs its own term search functions, however, and, in the anticipated integrated version, use of RECON's existing search routines may reduce THESGRAF's functional scope. In any case, the file size independence provided by random access methods is essential, to prevent response time from degrading badly for large thesauri.

When the target term is located, the "term paragraph" containing all its associated terms is read in. The paragraph is then analyzed to determine how each term is related to the main term. Screen coordinates are computed for the terms, and preliminary vector endpoint indices are assigned to ultimately allow lines to fan out from the main term to nearest neighbors. Final vector endpoint calculations are performed when the paragraph has been completely processed. Foreground/background color, character height and case are determined, and display characters are packed to configure the final output string.

Following this process, a screenload of terms from the main term paragraph is output as a string to the user terminal. The terminal interprets the ASCII command string, writes the terms at their assigned positions on the screen in their assigned colors, cases, and heights, and constructs interconnecting vectors as appropriate.

If a given paragraph has more terms of a given type than can be simultaneously displayed on the screen, the user can interactively scroll the individual columns up or down. When scrolling, the program adjusts columns so that they are headed by a broader/narrower term at the highest column level (BT1/NT1) rather than beginning somewhere within a BT2/NT2 list.

If a light pen is used to enter the next main term, the program senses a control character from the terminal specifying the next two characters as the pen's x,y focus on the screen, determines which term is presently at those coordinates, and supplies that term to the search algorithm as if it had come from the keyboard. Error traps prevent processing of inadvertent or extraneous input.

SUMMARY

On the spectrum of program complexity, THESGRAF is extremely simple, yet it makes a significant improvement in the utility of a thesaurus. The key appears to lie in providing information space perspectives to the user natural to his view of the domain; the more simply this can be done, the easier the implementation becomes. In completely interrelated data structures, less appropriate representations place inconvenience burdens on the user, or, in extreme cases, obscure significant data relationships altogether. In our work, limitation of the display bounds within the information space has proven valuable in maximizing user convenience, but this would not have been practical without simultaneous provision of an easy method of flipping screen pages. THESGRAF, we feel, is a bellweather of interfacing techniques on the horizon in information science; as a group, these techniques should greatly expand the usefulness of many types of information systems, both by enabling experienced users to expand the sophistication with which they can manipulate the system and by extending system access to casual users with no desire to learn the system's intricacies, but with a need for the information it contains.

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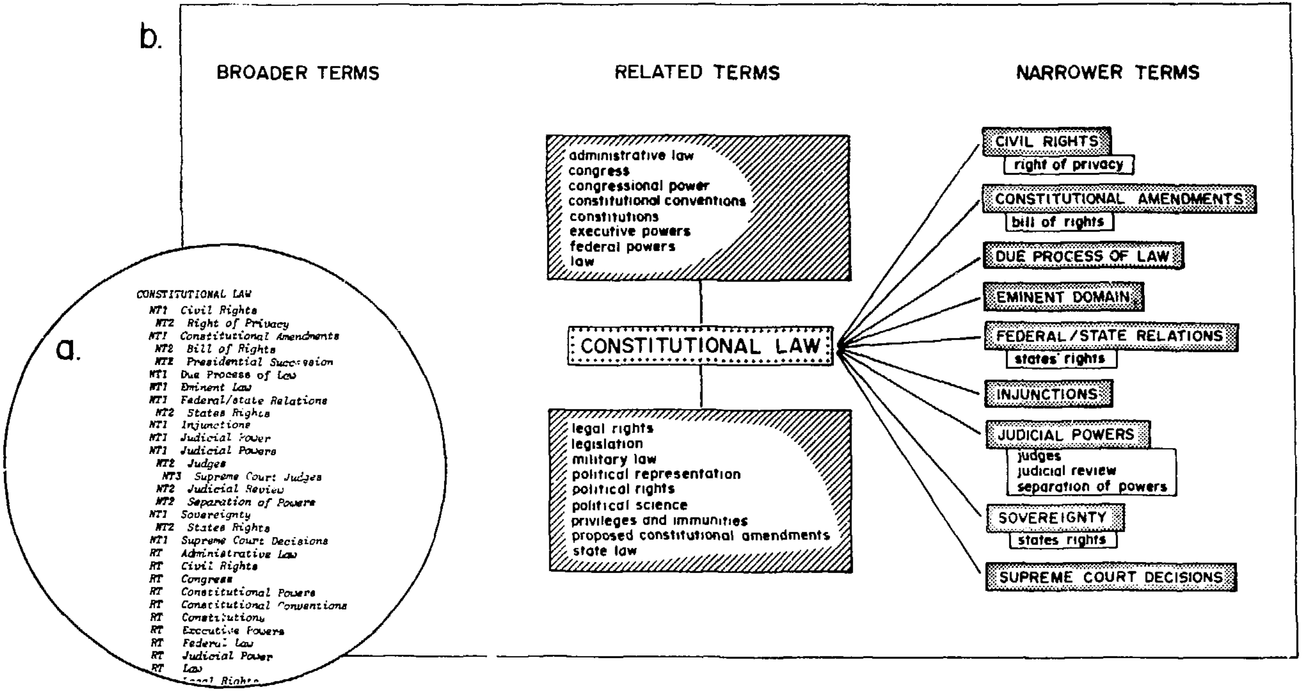

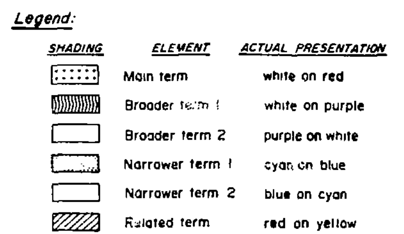

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Figure 1: Typical thesaurus paragraphs in traditional tabular-alphabetic (a) and computer graphic (b) presentations. Shading has been substituted for the color-keying used in the actual computer graphic displays, but the clarity improvement is still apparent. The paragraph's main term (MT) appears at screen center, broader terms up to two levels distant (BT1, BT2) in the left column, narrower terms (NT1, NT2) in the right column, and related terms (RT) in column with the main term. The hierarchical terms are grouped in BT1/NT1 units, and the units are linked to the main term with vectors. Each presentation screenload is restricted to five hierarchical levels.

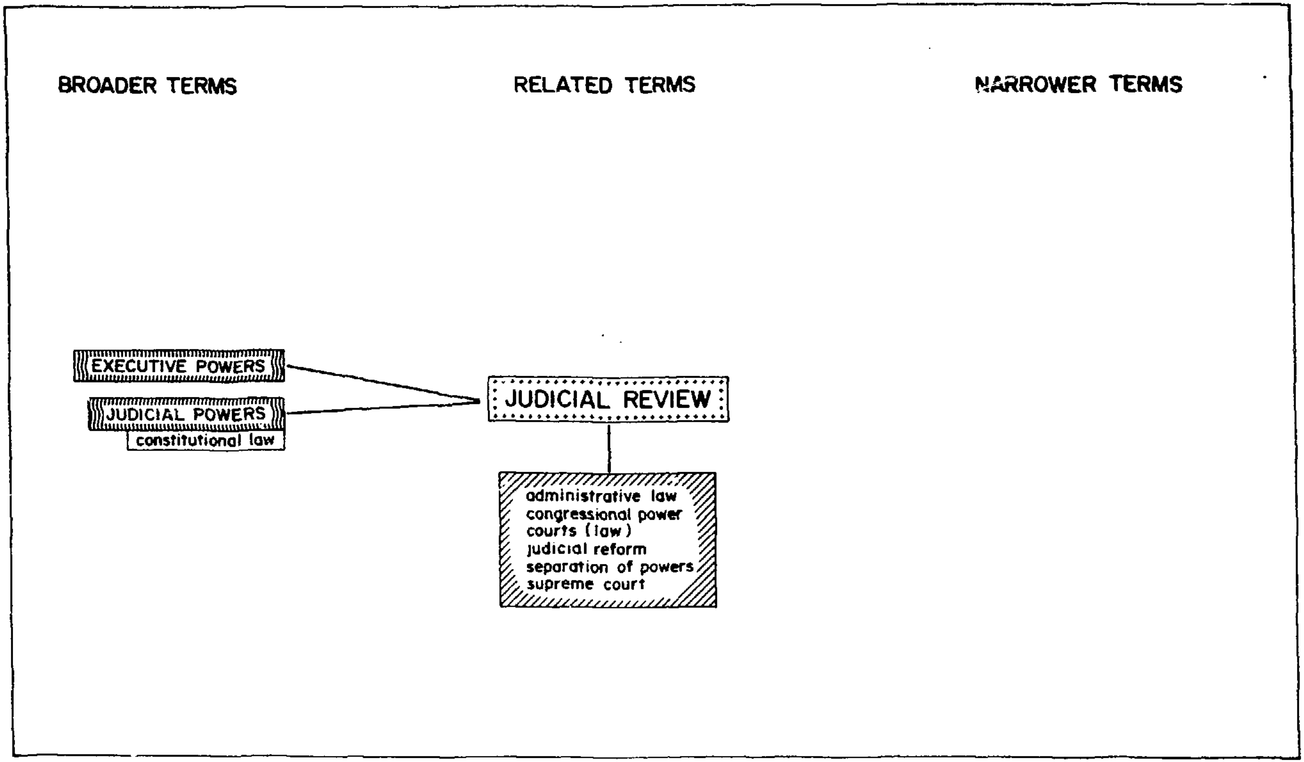

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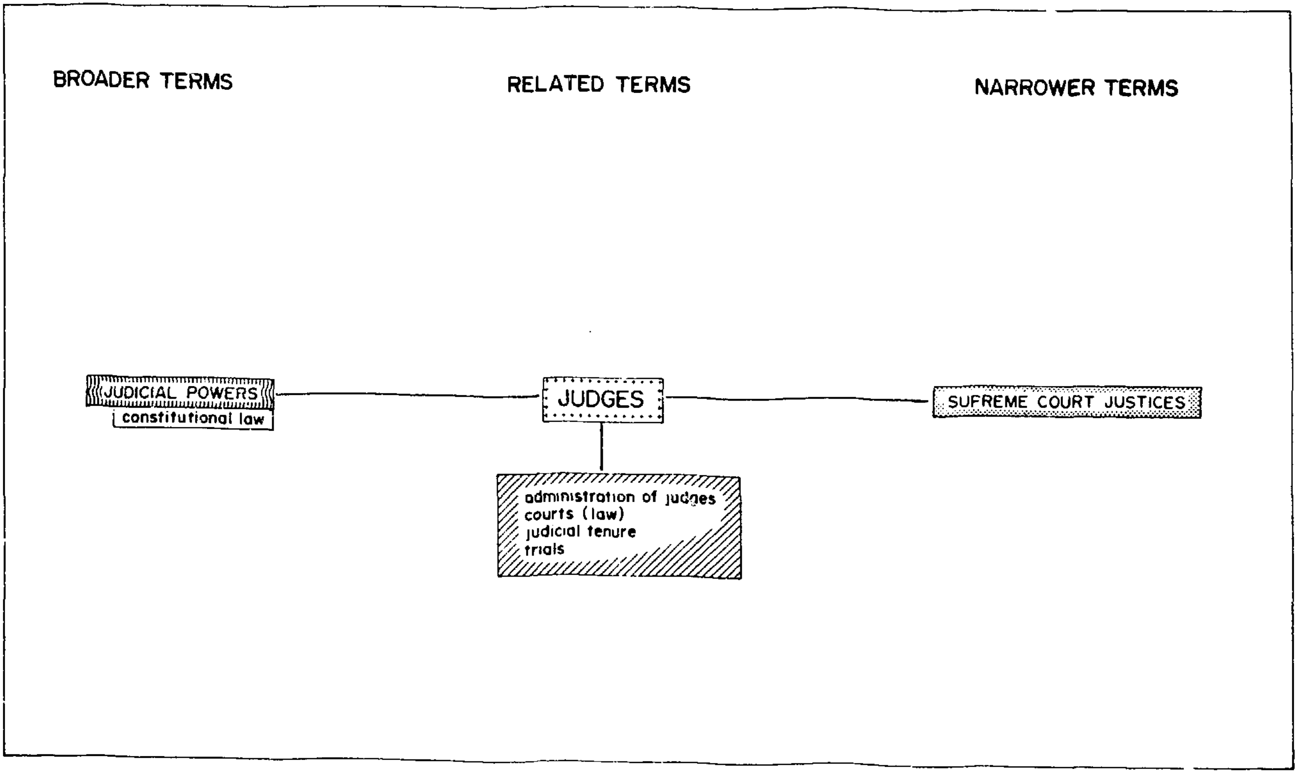
Figure 2. Thesaurus neighborhood from the perspective of a grandchild of the Figure 1 main term. 'Constitutional Law' is a BT2 to the main term expanded here, 'Judicial Review'. Note that 'Executive Powers', an additional BT1 parent, comes from a distinct hierarchical term family and was not visible from the perspective of Figure 1. Similarly, the RT groups for the two main terms differ radically.



XBL 804-9038

Figure 3. Thesaurus neighborhood from perspective of a second grandchild of the Figure 1 main term. While 'Judicial Review' was at the bottom of a term chain, 'Judges' has an additional depth level below it.