

PROCEEDINGS OF THE 3rd ASIS SIG/CR CLASSIFICATION RESEARCH WORKSHOP

Improving Intellectual Access to Material: An Online Browser for the Dewey Decimal Classification System.

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A report of research aimed at developing a technique that will automatically group similar books into clusters by subject and then organize these clusters hierarchically using the Dewey Decimal Classification Scheme so that users can broaden or narrow their searches at will. The software we have developed, uses an object oriented graphical user interface to facilitate browsing through the schedules.

We studied the relationship between class numbers and subject headings and determined that the class number addresses the major focus of the work while the first subject heading represents the aboutness of the book. They are different and complementary. It was also evident that there was a classic many to many relationship between Dewey's and subject headings. We therefore decided to develop clusters based on the unique class number/subject heading combinations. We will discuss our experience with determining the optimum cluster size in a database of 100,000 records.

Having manipulated the cluster size by altering the number of digits in the Dewey number, we then looked at the subject headings. Each subject heading has the potential for one or more subdivisions. We found examples with as many as 4 subdivisions or facets as we have chosen to call them. Out of the 65,904 subject headings only 16,290 had no facets. This means that 75% of the headings have one or more facets, while 6,291 or 14% of the headings had two or more facets.

Our research has focused on search systems that manipulate subject clusters by combining subject headings and class numbers in new and interesting ways. Particularly powerful is the ability to keyword search through Dewey to find the relevant class number and then to be able to display the subject headings of books in that class. More interesting is the study of the clustering behavior in the system.

I. NEED TO BROADEN OR NARROW SEARCHES.

One of the major complaints about most present text retrieval systems is the lack of support for finding alternative keywords (Cochrane, 1986). Once a search is under way, support for navigation is limited to recording the results of previous searches or, in a hypertext interface, recording which screens a user has visited. Few, if any, tools are available to help the searcher broaden or narrow the scope of their search. Some systems, such as the Carlyle Tomus software designed for library books, have attempted to solve this problem by offering an alphabetical display of Library of Congress Subject Headings (LCSH) in which the word was found, with the possibility of using the broader, narrower and related terms built in to LCSH for further browsing. There are several problems with this approach:

1. The controlled vocabulary of LCSH is very restrictive and results in over 30% failed searches (Alberico & Micco, 1989). The terms that are found are by definition broad, since they represent the whole book level. Without a lead-in vocabulary the user must start the whole process over again from scratch when a search fails.
2. The syndetic structure of LCSH rapidly leads the user away from the topic of interest (Sinkankas). It is not by its nature a hierarchical scheme having no more than three levels at any entry point (Broader, Narrower and Related Terms). Also the system of cross references is designed for manual searching and therefore many of the references deal with changes in word order and minor variations in stems. e.g. suicide see suicidal behavior; see also Women--suicidal behavior. What is needed (Bates) is intelligent software that will enable the user to access the database from any natural language term and then use the controlled vocabulary to broaden or narrow their search based on how dense the literature is at that point. (how many hits)

II. NEED TO KNOW THE CONTEXT IN WHICH WORD WAS FOUND.

In "brute force" keyword search systems, where the system looks for a literal match for the keyword input, the user is told how many times a particular word appears in a specific database, but no context is provided. For instance, searching for the keyword "bank" could produce entries on interest rates; it could also produce entries on how to maneuver an airplane, or what river banks are best for fishing. There is no ability to organize this output and very few means for the user to select subsets in an intelligent or reasonable way. No context is provided for a user until he or she reaches the actual book level. There are no intermediate levels of abstraction. It would be very helpful if all the entries on interest rates were grouped into a single subject cluster. The user could then quickly determine if this cluster was of interest.

Psychologists and English teachers tell us that the context in which a word is used is critical to its meaning. Banks in Finance are very different from Marine Banks, which are different again from Sir Joseph Banks, the botanist. The context could easily be provided by showing how the cluster fits in the universal tree of knowledge.

III. VALUE OF A HIERARCHICAL CLASSIFICATION AS A BACKBONE.

The effectiveness of using an underlying numerical classification in online text databases has been amply demonstrated by the considerable success of the Medlars systems (Micco, 1980) but most other vendors have seen no reason to make the investment required to introduce classification as a means of organizing materials. In Medlars, users are able to move up and down the numerical tree structure to find the appropriate level of specificity and to determine the correct terminology (Lancaster). In effect they are browsing the subject area. They can also take advantage of the tree structure to explode a topic capturing all subsets within a given set as identified by the class number. Our research has focused on implementing a similar hierarchically organized system of

subject clusters in the Marc database for books and non-print materials by taking advantage of the class numbers that are already built in. Our goal was to facilitate broadening or narrowing searches by using the underlying classification. The system was designed to be reverse engineered with little or no manual intervention. The clustering algorithms we have developed can in fact be applied to any database that has implemented a controlled vocabulary managed in a thesaurus. Several have objected that no classification numbers (class numbers) are provided for periodical articles, but each periodical is assigned a class number and this serves to provide a context for the article. E.g., an article on CD-Rom Databases found in the Journal of Technology in Education (education) is very different from one found in Communication of the Association of Computing Machinery (Computer science).

In the Marc database for books each record is assigned a numerical class number which serves to locate the work on the shelf. This number represents where the book fits best in the universal tree of knowledge, its context if you will, and much time and effort is invested in ensuring that the number is meaningful, yet no effort is made to capture this information in current online systems. No systems that we are aware of, provide the English captions for these class numbers on-line, even though they represent a valuable source of additional keywords. Except for a very primitive shelflist option which is well hidden from the average user, the classification number is ignored; Part of this is due to the limitation of the Library of Congress Classification schedules. The notation system they have chosen to use is enumerative not hierarchical and does not meaningfully reflect the actual subdivisions of the topics. The classification schedules have not yet been fully automated and the English captions are not available in machine readable form. For these reasons we decided to use the Dewey Decimal Classification System R (generously provided by OCLC and Forest Press) and were able to obtain a cross section of the English captions to the fifth level (5 digit numbers) to use in our experiments. (Note: none of the standardized table headings were included in the set of captions provided hence we reverted to the 3 -digit caption when a gap occurred. We are working on solving this problem now).

IV. ROLE OF SUBJECT HEADINGS

Our goal was to develop an intermediate level of clusters that would group books on similar topics together and then could be displayed for users to select the topic of interest from the set of hits obtained in their keyword search. A search for the keyword "darkness" in all tags yielded a wide variety of clusters or contexts. See Figure 1. Note that with our software, users can elect to sort the clusters alphabetically or by class. Here they have been sorted by class to show more clearly the different subject areas covered: philosophy, sociology, economics, folklore etc.

With our database of 100,000 records we found that using the full class number we obtained 28,951 clusters averaging 3.45 books per cluster. Extrapolating to 22 million books however it was very difficult to predict when the number of new clusters would taper off and each cluster start to grow in size. But we were certain that some of the clusters would become unreasonably large unless we could find some way to break them down further. We decided to explore the possibility of using the subject headings assigned as a way to break down the class clusters. We were also interested in studying the relationship between the two.

IUP Data

darkness

EXACT MATCH m BEGINS WITH b APPEARS ANYWHERE n

SORT BY TOPIC i SORT BY CLASS CODE c

START NEW SEARCH s REVIEW SEARCH HISTORY h

Number Of Books Found: 253; Number of Subject Headings Returned: 53

Change Current Search

FAIRLY n

EXPAND o

NARROW n

TO BROWSE SHELF SELECT A CALL NUMBER FIRST

BROWSE SHELF B Call

CLASSIFICATION

Humankind

Sensory perception/emotions/physiological di

Sensory perception/emotions/physiological di

Ethics (Moral philosophy)

Other ethical norms

Oriental philosophy

Oriental philosophy

Christian theology

Christian church in Asia

Roman Catholic Church

Comparative religion

Other religions

Sociology and anthropology

International relations

Economics

Folklore

His/geog/modern variations

Specific celestial bodies and phenomena

Mining and related operations

SUBJECT HEADING

Life--Addresses, Essays, Lectures

Vision

Vision

Youth--Conduct Of Life

Joy And Sorrow

From Darkness To Light

Philosophy, Jewish

Salvation--Early Works To 1800

Japan--Church History--20th Century

Catholic Church In Russia

Experience Religion

Mesopotamia--Religion

Afro-Americans--Segregation

United States--Foreign Relations--China

Appalachian Plateau--Economic Conditions

Witchcraft--Addresses, Essays, Lectures

Short Stories, Icelandic--Translations Into English

Eclipses, Solar

Coal Mines And Mining--West Virginia--Act

DEWEY (abbr.)

128

152

152

170

179

181

181

230

275

282

291

299

301

327

330

398

437

523

622

TITLES

3

3

3

7

1

2

7

1

1

1

1

1

5

14

1

1

1

1

DETAIL OPTIONS

Get Book

Review r

PRINT

Help ?

QUIT

Figure 1: Search for Clusters for Keyword 'Darkness' (using LC class numbers)

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One option we considered seriously was to substitute the subject headings for the English captions but each book is assigned a subject heading that most closely represents its "aboutness", and not necessarily the "aboutness" of the group of books as a whole. e.g. the class number for National Socialism 320.53 includes a book that deals with Hitler and his contribution to National Socialism. The first subject heading assigned is Hitler, Adolph. This heading accurately represents what this particular book is about, but it was never intended to convey the overall subject of the class number to which the book was assigned. The two systems, class numbers and subject headings are different and complementary.

Another difficulty is that each book has the potential for more than one subject heading. For example a book on Logic and Structured Design for Computer Programmers is assigned to 005.131 which is for books on programming. This is reflected in the first (primary) subject heading: Electronic Digital Computers-- Programming. Two other headings (secondary) bring out other aspects of the topic: Structured Programming; Logic, Symbolic and Mathematical. If a different cluster is made for each of the three subject headings, the book has in fact been listed in three different clusters and we will end up with more clusters than books, thereby defeating our objective which was to provide an intermediate level of grouping by placing similar books together in meaningful clusters. It would also be very misleading since the user would be led to assume that books on Logic, Symbolic and Mathematical were to be found in 005.131. To solve this problem, we worked with the Library of Congress Subject Cataloging Policy division and determined that in fact the first subject heading assigned to each book represents its "aboutness". While the class number represents a more general heading for all the books on the topic as a whole. See Figure 2 which shows all the primary subject headings for books classified in 616.24 Diseases of the lungs. The primary subject headings in fact serve as narrower terms. To see related terms the user can browse the Dewey table as shown in Figure 3 perhaps selecting 616.23 Diseases of the Trachea and Bronchi. Broader terms can easily be found by moving up one or two levels in the summaries. In Figure 4 we show using the Third Summary for medicine.

As a result of our findings, we set a policy that each book would be assigned to only one cluster, represented by the class number and the first subject heading assigned to the work. The other subject headings would still be searchable but they would serve as see references, pointing to the cluster instead of the books themselves. The person searching for books on Hitler would find a number of different 3 digit class numbers to choose from.

070 Documentary Media; Educational Media; News media; Journalism; Publishing;
296 Judaism
301 Sociology and anthropology
320 Political Science, Politics and Government
923 Persons in the Social Sciences-biography
940 General History of Europe, Western Europe.
943 History, Central Europe

We decided it would be helpful to display both the primary subject heading and the english caption for the class number. The obvious question then was what is the degree of overlap. Unfortunately we only had captions for a cross section of 5-digit Dewey numbers so that we could not obtain any

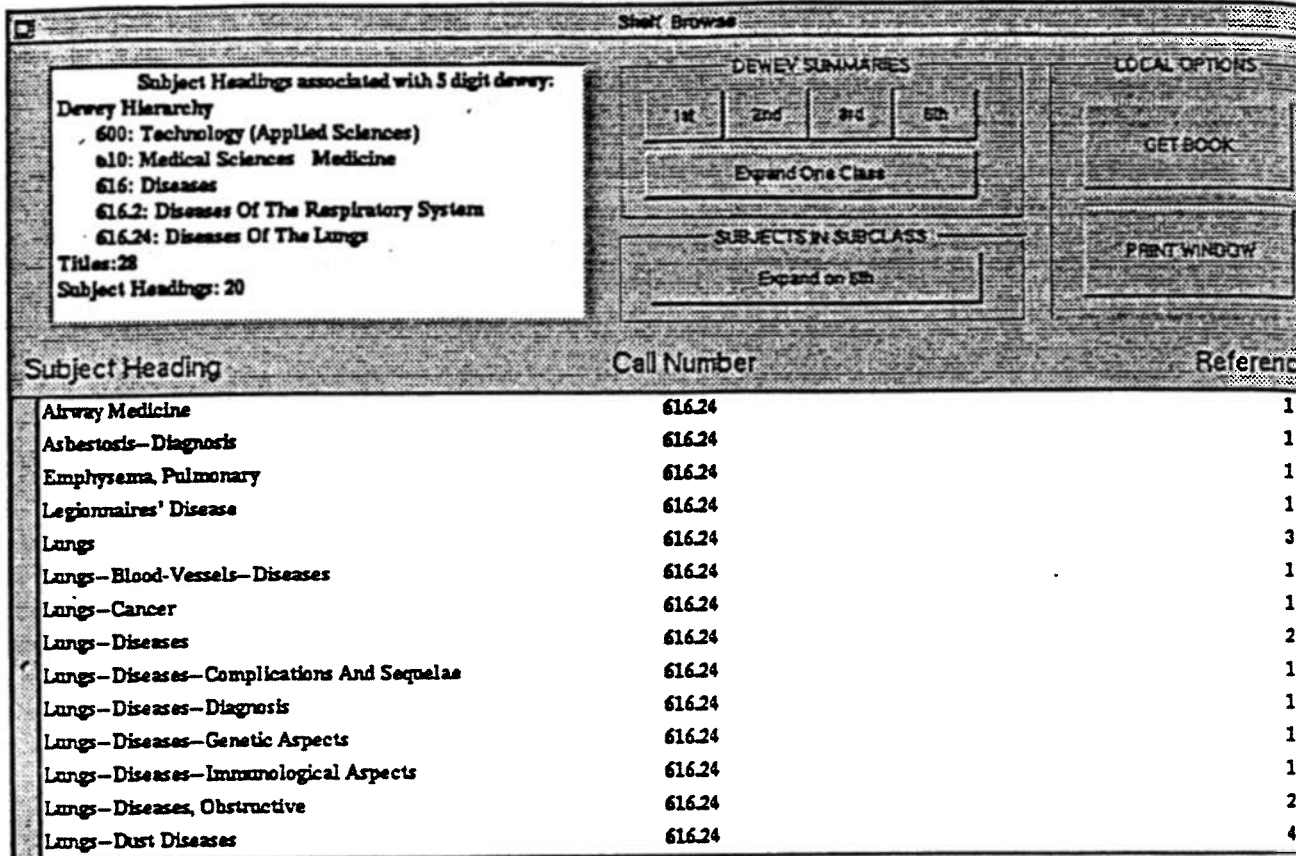


Figure 2: List of Different Subject Headings associated with 616.24 --Narrower Topics. (using Dewey Decimal Classification R)

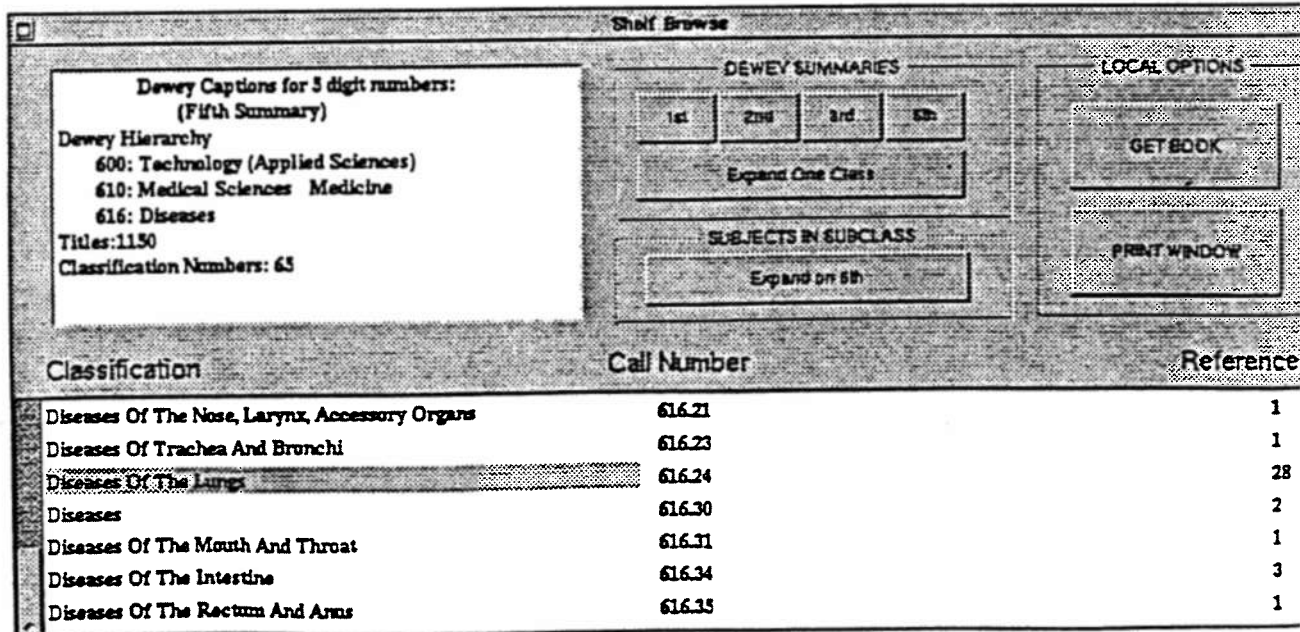


Figure 3: Display of Dewey Summary using 5 digits and Associated English Captions--Related topics.

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Dewey Captions for third Summary:
The 1000 Divisions

Dewey Hierarchy
600: Technology (Applied Sciences)
600: Technology (Applied Sciences)
Classification Numbers: 105

DEWEY SUMMARIES
1st 2nd 3rd 5th
Expand On Class

SUBJECTS IN SUBCLASS
Expand on 5th

References

Subject	Call Number
Education, Research, Related Topics	607
Inventions And Patents	608
Historical, Geographical, Persons Treatment	609
<i>Medical Sciences Medicine</i>	610
Human Anatomy, Cytology (Cell Biology), Histology (Tissue Biology)	611
Human Physiology	612
Promotion Of Health	613
Forensic Medicine, Incidence Of Disease, Public Preventive Medicine	614
Pharmacology And Therapeutics	615
Diseases	616
Miscellaneous Branches Of Medicine Surgery	617
Other Branches Of Medicine Gynecology And Obstetrics	618
Experimental Medicine	619
<i>Engineering And Allied Operations</i>	620
Applied Physics	621
Mining And Related Operations	622
Military And Nautical Engineering	623
	4
	24
	331
	38
	352
	304
	258
	304
	1140
	143
	232
	1
	160
	493
	93
	78

Figure 4: Dewey Third Summary--Broader Topics

reliable data on the degree of overlap but for the 100,000 records using 5 digit dewey numbers in our database we found only a 4% overlap. This was much lower than expected.

The software searches a central dictionary of all keywords in the system and then displays by default the subject clusters in which the word was found. We selected the cluster in 923.14 --Hitler, Adolf with 17 books for further expansion.

Class caption for Dewey truncated to 5 digits:

Biography, Genealogy, Insignia
Persons in Social Sciences
Heads of State
Europe

Primary subject headings assigned.

Hitler, Adolf,--1889-1945
Hitler, Adolf,--1889-1945--assassination--

Secondary Subjects:

Anti-nazi movement
Generals--Germany
Germany--foreign relations--1933-1945
Germany--history--1933-1945
Germany--history--great blood purge, 1934
Germany--politics and government--1918-1933
Germany--politics and government--1933-1945
Heads of state--Germany--biography
Hitler, Adolf, 1889-1945--correspondence, reminiscences, etc.
Hitler, Adolf,--1889-1945--manuscripts--facsimiles
National socialism
Nationalsozialistische deutsche arbeiter-partei
Nationalsozialistische deutsche arbeiter-partei--
Psychohistory
World War, 1939-1945--Germany
World War, 1939-1945--occupied territories

If the user then decides that they want the book that covers Psychohistory it is a simple matter to select that one from the set. Conversely if the user keys in the natural language term "psychohistory" they will be shown that one of the clusters for that topic is 923-Hitler, Adolph. Clearly the secondary subject headings are serving to bring out additional aspects of the books and do not reflect the "aboutness" of the class number. It is unfortunate that some library vendors have

chosen to rearrange the order of the subject headings numerically thereby losing the distinction between primary and secondary subject headings. This is an important distinction which can be very effectively exploited in online systems as shown.

V. MANIPULATING CLUSTER SIZES

A. Finding a reasonable cluster size in proportion to collection

Our goal was to preprocess the collection to develop an average cluster size of between 10 and 50 books each. We hoped in this way to ensure that when a user entered a keyword they would not get hundreds of entries with little more than one book per cluster. We know from our research with the Melvyl database using subject headings alone, over 80% of the clusters in our sample were less than 5 books with the result that an average search yields over 171 entries. In the 10 year catalog of Melvyl, in 25 randomly selected searches all but four of the keywords yielded over 100 subject headings. A search for items on JAPAN found over 11,200 subject headings!! We need to find ways to cluster books meaningfully into larger groups to help users to gain a bird's eye view of the materials available. Clearly there is an inverse proportional relationship between cluster size and number of clusters retrieved. The larger the clusters the fewer clusters are retrieved!!!

In our collection of 100,000 books we used only 3 digit Dewey's combined with subject headings to ensure adequate clustering. For between 500,000 and 1 million probably 5 digit Dewey's will work best. As the number of books increases the number of digits can be varied. This will only work in a hierarchical scheme. Our earlier research has already established that most searches for a keyword turn up a number of different class numbers as well as an even greater number of subject headings. We expected to find a one to one ratio of Dewey numbers to subject headings but this proved not to be the case. There was a classic many to many relationship. Each Dewey number was linked to several subject headings, while most subject headings could be found in more than one 3 digit Dewey class. For this reason we decided to develop a system of subject clusters based on the unique class number/subject heading combinations; We experimented with a number of different combinations for developing clusters in our database of 100,000.

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1. Using subject headings only: 65,904 clusters per 100,000
 2. Using the full Dewey number: 28,951 clusters
 3. Using Dewey abbreviated to 5 digits: 11,263
 4. Using Dewey abbreviated to 3 digits: 912 clusters
 5. Hybrid: using Dewey (3 digits) and subject headings 83,551.
 6. Hybrid: using Dewey (5 digits) and subject headings 94,892.
-

B. Dealing with large sets of clusters

While we could manipulate the average cluster size by adjusting the number of Dewey digits being used to ensure that a reasonable number of clusters would be retrieved, this did little to deal with the very large sets of clusters found in 15% of the database for keywords like international or united states. Unfortunately these very large sets of clusters also represent in many cases the most frequently used headings.

To solve this problem we looked at the possibility of manipulating the subdivisions of the subject headings dynamically during a search to vary the cluster size. Each subject heading has the potential for one or more subdivisions. We found examples with as many as 4 subdivisions or facets as we have chosen to call them. Out of the 65,904 subject headings only 16,290 had no facets. This means that 75% of the headings had one or more facets, while 6,291 or 14% of the headings had two or more facets. Here we are using Neelameghan's definition of a facet as a generic term to denote either the basic subject component or the isolate component in a compound subject. For a search yielding an unwieldy number of very small clusters it would be possible to reduce the number of clusters by simply collapsing the facets into each other. For example all of the following clusters could be folded into one under Lung--Diseases

Lung--Diseases--Complications and Sequelae
Lung--Diseases--Diagnosis
Lung--Diseases--Genetic Aspects
Lung--Diseases--Immunological Aspects
Lung--Diseases, Obstructive

As we studied optimum clustering with hybrid clusters, it became obvious that this could be readily manipulated based on the size of the collection. In a small collection the clusters could be restricted to the first 3 digits and the first subject heading without any subdivisions. On the other hand we are predicting that we could comfortably accommodate a collection of 22 million books without unmanageably large clusters, by using the full class number combined with the full subject heading with all its subdivisions. To verify this conclusion, we obtained an account on Melvyl and used the 10 year catalog to derive and study the use of faceting or subdivision. in a sample group of 25 headings. To our surprise we found that 80% of the subject clusters with all levels of subdivision have 5 or less books. It is in the remaining 20% that the difficulty occurs. These large clusters occur most frequently under the subject headings with no subdivisions and where only one high frequency subdivision has been used such as history.

C. Use of Filters

We also noted with interest that 70% of all subdivisions are geographic. If these could be filtered out when not wanted, the retrieved sets would be considerably reduced. Returning to our database of 100,000 where we had the ability to manipulate the data, we explored other possible filters. We found that period subdivision (y or d subfields) occurred in 17348 records or 17.3%, while place (z subfields) were used in 19,997 or 19.9%. As expected free-floating subdivisions (x subfields) are used much more heavily: 40,861 occurrences or 40% of the records. We also noted that of all the free-floating subdivisions (x), only 88 occurred more than 100 times in the database or in more than 1% of the records. We considered these as a suitable list of high frequency headings to display for those seeking help in subdividing a large set. More than half of these high frequency headings were form headings. We would definitely support the recommendation that form headings be given a different subfield delimiter. All of these specialized facets can be selected or screened out to reduce the number of clusters being presented to the end user. In Figure 5 we show a search for mathematics where only the free-floating subdivisions are shown. Our research has focused on

The screenshot shows a web-based interface for searching the Dewey Decimal Classification System. At the top, there are navigation links like 'Home', 'About', 'Help', and 'Options'. Below these are search filters: 'Change Current Search', 'GROUP', 'EXPAND', and 'FILTER'. A search bar contains the text '35 X subdivisions Found for: mathematics'. Below the search bar, there are several search options: 'WITH CURRENT SEARCH', 'HIGH FREQ FORMS WITH CURRENT SEARCH', and 'AS SEPARATE SEARCH'. The main area displays a list of results categorized by subject, with a 'Mathematics' column on the left and various subfields on the right. A 'Form' button is visible at the bottom of the search area.

Mathematics	Addresses, Essays, Lectures	Aids And Devices	Audio-Visual Aids	Authorship
	Bibliography	Collected Works	Collections	Computer-Assisted Instruction
	Congresses	Data Processing	Dictionaries	Early Works To 1800
	Education	Examinations, Questions, Etc	Formulae	Foundations
	Handbooks, Manuals, Etc	History	Indexes	Mathematics
	Methodology	Periodicals	Philosophy	Popular Works
	Problems, Exercises, Etc	Programmed Instruction	Psychological Aspects	Study And Teaching
	Study And Teaching Elementary	Study And Teaching Higher	Study And Teaching Primary	Study And Teaching Secondary
	Tables, Etc	Teacher Training	Text-Books	

Figure 5: Use of Filters: Restricting a Large Set to Display of Free-Floating Subdivisions only (X subfields).

search software that manipulates subject clusters by combining subject headings and class numbers in new and interesting ways. Particularly powerful is the ability to find relevant subject clusters and then to be able to manipulate the displays of the subdivisions for headings in those clusters.

VI. ABILITY TO BROADEN OR NARROW SEARCHES

The question was then, could we somehow provide the user with the ability to broaden or narrow a search by taking advantage of the Dewey classification numbers in an online display. This work builds on the research done by Karen Markey and Diane Visine-Goetz(1988). A search for asbestosis provided several clusters to search. From there the user requested the Browse Shelf option to see what other subject headings had been assigned to a selected class number: 616.24 as shown in Figure 2.

The hierarchy is displayed in the upper left hand corner and the user can readily see that the class 616.24 is used for Diseases of the Lungs, of which Asbestosis is only one. Other options include Pneumonia and Pulmonary Edema. Even with only 100,000 books in the collection, we had 28 that dealt with Diseases of the Lungs and the subject headings provided a very useful breakdown. For each subject heading/class number combination we show the number of books and the user can elect to view the books highlighted by selecting the Get Book option.

From this display the user can move up to the summaries to see what other Dewey numbers are in proximity. We chose to use the 5 digit Summary and then the third Dewey summary. The user who decides to browse can pick any summary. In Figure 3 we chose the fifth summary and begin the display with the chosen number 616.24. The user can scroll through the section from 616.00 to 616.99 and examine the captions. If they find a different class number that seems better suited to their information need, they can expand it to capture the subject headings for it also. Users can move freely from one display to another in any order. See attached Figures.

VII. CONCLUSION

New more powerful computers and much more sophisticated software make possible new approaches to intellectual access. We have been exploring different ways to exploit the linkages between Dewey Decimal Classification numbers and LCSH subject headings to address the problem of helping users to find alternative keywords by broadening or narrowing their search (Books are for Use). The importance of a hierarchical notation in achieving this objective cannot be overstated. It is a major drawback of the Library of Congress notation system as it is an enumerative scheme with little correspondence to the actual subdivisions of the topics. We hope that the Library of Congress Classification notation will be upgraded so that it too can support the kind of hierarchical browsing being proposed. This could easily be accomplished by adding unseen machine codes that would be translated to the LC notation for display. The search system we have built and tested depends on an underlying system of subject clusters based on class number/subject heading combinations.

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VII. RECOMMENDATIONS FOR FURTHER RESEARCH

The database we experimented with had only 100,000 records, too few to really study the clustering behavior evident in a large general collection. We predict that around 500,000 books the number of new clusters being added will begin to taper off and clusters will instead increase in size. How best to manipulate cluster sizes is another fruitful area for further research. It should be possible to predict the correct number of Dewey digits to use to obtain a reasonable average cluster size of say between 50-100 by the number of books in the collection. Users can then break down the 10% of very large clusters by dynamically manipulating the number of subdivisions displayed for each heading.

Unfortunately we did not have all the captions for the Dewey class numbers as OCLC only provided captions up to five digits. The other unsolved problem was how to deal with the many tables used by Dewey.

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