X. TEST DESIGN AND DETAILED RETRIEVAL RESULTS

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SUMMARY

This part describes a number of initial experiments in document retrieval conducted with the SMART system. A set of retrieval requests is processed against a reference collection of 405 abstracts of articles in the computer field. The experiments are designed to determine the influence on retrieval performance of such systems parameters as the thesaurus transformation, concept weighting, the concept hierarchy, phrase-searching techniques, and request-document matching techniques. The detailed experimental results are included.

1. Current Status of the SMART System

At the present time the SMART system is operating as a document retrieval system oriented towards the computer-allied literature. Retrieval requests are matched against a reference collection of 405 abstracts of documents in the field, taken from the IRE Transactions on Electronic Computers (March, June, and September 1959). The semantic dictionaries of the system are in part tailored to this collection so that, in general, most content-bearing words in these abstracts are included in the dictionary. This fact should be taken into account when judging the experimental results. Future experiments are expected to include other reference documents not previously used in the construction of the dictionaries; this may provide

a more direct indication of system performance. When the system operates with the so-called "null" thesaurus, that is, with concept classes which are in one-to-one correspondence with the word stems, all stems occurring at least four times in the reference collection are taken into account in the matching procedure between documents and search requests. This arises from the fact that the one-to-one word stem to concept (null) dictionary is constructed automatically from the reference collection (Information Storage and Retrieval, Report No. ISR-7, Sec. XI). All frequently occurring stems are then automatically included in the null thesaurus.

The thesaurus transformation was originally constructed empirically (see Information Storage and Retrieval, Report No. ISR-7, Sec. VII and Sec. VII of the present report). Several important features of the regular (Harris) thesaurus are summarized below.

(1) The mapping is many-to-many from word stems to concepts.

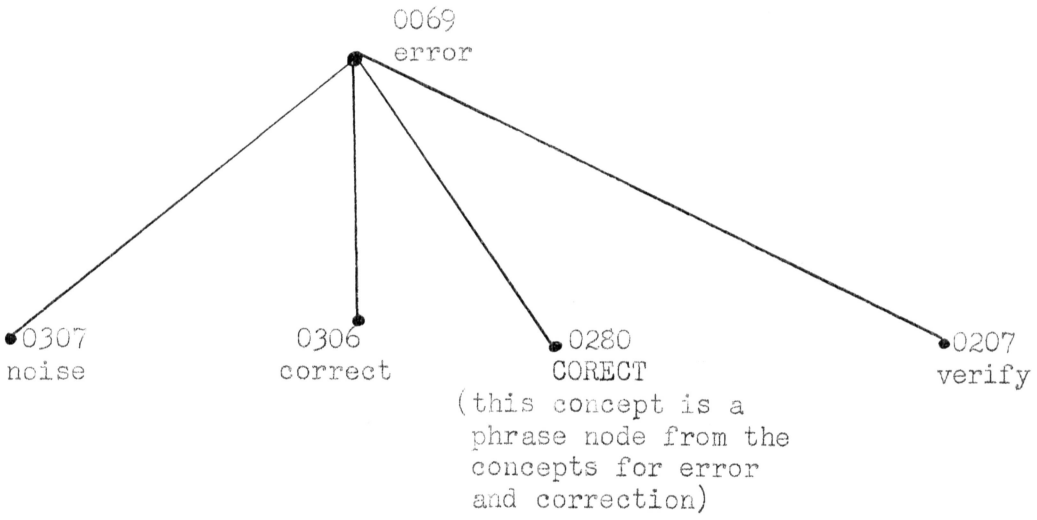
(2) Certain morphological variants of a given stem may be specifically entered into the stem dictionary, if warranted by semantic considerations. For example, the concept assigned to "programming" might be different from that assigned to "program," if this were desired. This might be done simply by entering "programming" into the dictionary along with the stem "program." Thus the transformation may deviate somewhat from a strict word stem to concepts mapping.

(3) The thesaurus is designed such that the sum of the weights of the images of an input term is constant. Thus, if a term maps into a single concept, that concept receives a total weight of w in the resultant document image; if, on the other hand, a term maps into k concepts, each of these

will receive a weight of w/k. This constant weight scheme is designed to reflect term-concept ambiguity by giving more weight to unambiguous concepts. It is necessary to be aware of this fact, in order to be able to compare the results of retrieval operations using numeric vectors with those using logical document images. If logical (presence, absence) vectors are used, the effect of this weighting difference is lost as all concepts in a logical document image receive equal weight. The use of logical weighting then implies a loss of information about concept frequency (since a numeric weight assigned to a concept is equal to the sum of the weights derived from all terms of the document mapping into that concept). In addition, use of logical vectors results in a loss of information about concept ambiguity, which is reflected in the constant total weight technique.

(4) Concepts may be images of "phrases" as well as of terms (word stems), a "phrase" being defined by the phrase-detection scheme employed. Currently, two phrase-detection techniques are used: statistical phrases, in which a phrase is defined by the co-occurrence of concepts within a sentence; and syntactic phrases, in which the concepts in question must also exhibit a pre-specified syntactic relationship. Hyphenated terms, such as "solid-state" and "computer-oriented" are considered to be stems, and are entered explicitly in the dictionary under concepts which also include the phrases for the respective term pairs (without hyphen), for example, "solid state" and "computer oriented." Hence there arises no term-phrase dichotomy in the dictionary, in that some concepts are images only of individual terms, others are images of both terms and phrases, and still others of phrases alone. In some cases this gives rise to an anomaly

when the concept hierarchy is used. Whereas query or document images may be produced with or without phrase detection, the hierarchy consists of relations defined on all the concepts. Therefore, when the hierarchy is used on query images generated without phrase detection, a concept may be obtained which is the image of a phrase or phrases only (see Fig. 1). Clearly, this concept can never match any other in the text images under consideration if no phrase detection is used initially. This results in a general reduction in the correlation coefficient of the query image with



Excerpt from the Concept Hierarchy

Figure 1

all reference images, but is not considered to introduce a significant distortion, since the reduction acts uniformly over all reference documents.

2. Experimental Retrieval Requests

An initial set of retrieval requests was generated by members of the research group, with the aim of covering a cross-section of the major topics included in the reference collection. These requests are not tied to any particular reference documents, although the originators of the requests were to some extent familiar with both the collection and the system. It is expected that further experiments will be made with requests constructed by persons having no knowledge about either the collection or the system.

Relevance judgments for these initial requests were provided by the originators, and resulted from a full search of the total collection. In case of border-line relevance, either a consensus decision was made, or the document was assumed to be relevant. The relevance judgments may therefore be expected to include almost all the potentially relevant documents.

A. SPECIFIC REQUESTS

Request Identifier	Request Text	Relevant* Documents
Morse Code	Can handsent Morse code be transcribed automatically into English? What programs exist to read Morse code?	305 394
M2-Transmit	Digital data transmission systems and wire or microwave transmission systems.	40 51
Crystal Calcs.	What programs exist for X-ray crystallographic calculations? I am interested in the manipulation of observed crystal structure factors.	206 207 348
M3-Inform	Information theory and the mathematical theory of communication, code construction, code compression, coding theory, measure of information.	89 117 119
Random Numbers	How can one generate random numbers efficiently? Which pseudo-random sequences offer long periods and ease of generation?	91 94 237 300
Analog-Digit	Analog to digital conversion. Devices and techniques for coding of analog information.	42,46 157,165 296
IR-Indexing	Automatic information retrieval and machine indexing.	3,48 79,80 126,221

Retrieval Requests

TABLE 1

*The numbers are the IRE abstract serial numbers.

Request Identifier	Request Text	Relevant* Documents
Core Memory	What techniques are used in digital computer memories which are constructed with magnetic cores? Give circuit properties connected with addressing, sensing, and switching ferrite cores and magnetic properties of the ferrite materials used in computer memories. Consider both coincident current and linear select memories.	267 270 272 292 293 294 295
M10-Counters	Digital counters and registers, magnetic shift registers and counters, pulse counting circuitry.	5,21 22,143 144,145 149,284

B. GENERAL REQUESTS

Request Identifier	Request Text	Relevant* Documents
Automata Phr.	Automata theory. Computability and effective computability. Finite-state sequential machines. Türing machines and other tape automata.	129,176 241,264 313,315 316,371 372
Pattern Recg.	Tell me about pattern recognition. How are two-dimensional patterns scanned and encoded for a computer? What procedures are used to detect and identify alphabetic characters?	1,39 54,163 205,224 314,350 351,353

TABLE 1 (continued)

Request Identifier	Request Text	Relevant* Documents
Differentl Eq.	Give algorithms useful for the numeric solution of ordinary differential equations and partial differential equations on digital computers. Evaluate the various integration procedures (e.g., Runge-Kutta, Milne's method) with respect to accuracy, stability, and speed.	85,102 103,200 202,251 253,358 360,384 385,386 387,388 390
Solstat Circ.	Is there a discussion of the application of solid-state circuits to digital computers? I am interested in the use of transistors or diodes in logic and switching circuits, or in the realization of counters, shift registers, and gating elements.	9,12,13 22,25,27 133,141 143,145 177,267 273,278 279,281 291,304
M9-Watlarg	Mechanical translation; language analysis, dictionary lookup methods, automatic information retrieval, analysis of information, scanning and search systems, matching of information identifications.	3,48 79,80,81 112,113,114 115,116,125 126,162,183 221,222,223 255,314
Comp. Systems	Organization of digital computers. Logical design of computer systems. The structure of computing systems.	1,2,27,31,41 127,128,129,130 140,177,261,262 263,264,278,301 302,309,343,370
Comps. Assemb.	Compilers and assemblers, things like FORTRAN, FAP, and MAD. Systems programming and source language coding.	61,62,63,64,65,66 67,179,180,181,183 184,185,218,226,318 319,320,321,322,323 324,325,326,327,328 329,330,332,333,334
M8-Storage	Digital computer storage devices, memory devices such as magnetic disks, tapes, drums, and magnetic and ferrite core-storage arrays.	3,16,34,35,36 37,134,137,138,139 150,151,152,161,267 268,269,270,273,275 286,287,288,289,290 291,292,293,294,295

TABLE 1 (continued)

Table 1 lists the complete texts of the search requests used in the initial experiments. The serial numbers of the relevant documents for each request are also included.

3. Retrieval Experiments

The tests conducted to date center around an investigation of (a) the influence of the thesaurus, (b) the influence of phrase identification, (c) the influence of the structure of the text image, and (d) the effect of modifying search requests with the concept hierarchy. A group of 17 retrieval requests (described above) was used under the following conditions:

(1) concept classes derived from word stems on a one-to-one basis (null thesaurus), cosine correlation search;

(2) thesaurus derived concept classes, cosine correlation search;

(3) thesaurus derived concept classes, documents and query images weighted logically, cosine correlation search;

(4) thesaurus derived concept classes, overlap correlation search;

(5) thesaurus derived concept classes, document images derived from document titles only, cosine correlation search;

(6) thesaurus derived concept classes, with phrase detection (statistical) for queries only, cosine correlation search;

(7) thesaurus derived concept classes with phrase detection (statistical) for both requests and documents, cosine correlation search;

(8) thesaurus derived concept classes with phrase detection (simulated syntax) for both requests and documents, cosine correlation search;

(9) thesaurus derived concept classes with request altered by addition of "parent" terms from the concept hierarchy, cosine correlation search; and

(10) thesaurus derived concept classes with requests altered by addition of "filial" terms from concept hierarchy.

In the preceding list, query or document images are numerical (weighted) concept vectors unless otherwise noted. Simulated syntactic phrase detection refers to a procedure by which syntactic phrase lookup is hard-simulated by eliminating those statistical phrases which do not satisfy the syntactic constraint. The correlation schemes (cosine and overlap) are described in Information Storage and Retrieval, Report No. ISR-7, Sec. X.

Table 2 presents a detailed summary of the retrieval results for each query and the above processing schemes. The evaluation parameters presented are derived in Sec. III of this report. Table 3 gives averages of the normalized evaluation parameters over specific requests, general requests, and all requests.

A. SHORT SPECIFIC REQUESTS Request	Total Number Relevant	Word Stems Cosine	Thesaurus Cosine	Thesaurus Logical Cosine	Thesaurus Overlap	Thesaurus Titles Only Cosine	Thesaurus Stat. Phrases Queries Only Cosine	Thesaurus Stat. Phrases Cosine	Thesaurus Simulated Syntax Phrases Cosine	Thesaurus Hierarchy Up, Add. Cosine	Thesaurus Hierarchy Down, Add, Cosine
Morse Code											
#rel in 1st 15		2	2	2	2	2	2	2	1	1	2
rank recall		.19	.33	.60	.50	1.00	.20	.20	.11	.14	.33
log prec.		.26	.33	.50	.43	1.00	.26	.21	.15	.23	.33
norm. recall	2	.984	.99[illegible]	.998	.990	1.00	.986	.985	.970	.978	.992
norm. prec.		.82	.88	.94	.92	1.00	.83	.77	.65	.80	.68
WTED. norm. rec. and norm. prec.		1.74	1.84	1.93	1.90	2.00	1.76	1.70	1.50	1.69	1.84
M2-Transmit											
		2	2	2	2	1	2	2	2	2	2
		1.00	1.00	.60	.75	.10	1.00	1.00	1.00	.75	1.00
		1.00	1.00	.50	.63	.17	1.00	1.00	1.00	.63	1.00
	2	1.00	1.00	.998	.999	.968	1.00	1.00	1.00	.999	1.00
		1.00	1.00	.94	.96	.71	1.00	1.00	1.00	.96	1.00
		2.00	2.00	1.93	1.96	1.55	2.00	2.00	2.00	1.95	2.00
Crystal Calc.											
		3	3	2	2	3	3	3	3	2	3
		1.00	1.00	.27	.14	1.00	1.00	1.00	1.00	.32	.35
		1.00	1.00	.49	.32	1.00	1.00	1.00	1.00	.52	.54
	3	1.00	1.00	.987	.969	1.00	1.00	1.00	1.00	.989	.991
		1.00	1.00	.89	.77	1.00	1.00	1.00	1.00	.90	.90
		2.00	2.00	1.82	1.61	2.00	2.00	2.00	2.00	1.85	1.85

Retrieval Results For Individual Requests

TABLE 2

Request	Total Number Relevant	Word Stems Cosine	Thesaurus Cosine	Thesaurus Logical Cosine	Thesaurus Overlap	Thesaurus Titles Only Cosine	Thesaurus Stat. Phrases Queries Only Cosine	Thesaurus Stat. Phrases Cosine	Thesaurus Simulated Syntax Phrases Cosine	Thesaurus Hierarchy Up, Add, Cosine	Thesaurus Hierarchy Down, Add, Cosine
M3-Inform	3	3 .60 .60 .997 .92 1.90	3 .50 .53 .995 .90 1.88	3 .55 .59 .996 .92 1.90	3 .55 .65 .996 .94 1.92	1 .02 .20 .784 .57 .49	3 .50 .53 .995 .90 1.88	3 .60 .60 .997 .93 1.91	3 .60 .60 .997 .93 1.91	3 1.00 1.00 1.00 1.00 2.00	3 .60 .62 .997 .93 1.91
Random Numbs	4	4 .83 .89 .99[illegible] .98 1.97	4 1.00 1.00 1.00 1.00 2.00	4 .56 .63 .995 .91 1.88	4 .34 .53 .988 .87 1.81	4 1.00 1.00 1.00 1.00 2.00	4 1.00 1.00 1.00 1.00 2.00	4 1.00 1.00 1.00 1.00 2.00	4 1.00 1.00 1.00 1.00 2.00	4 .71 .79 .998 .96 1.95	4 1.00 1.00 1.00 1.00 2.00
Analog-Digit	5	5 .79 .63 .99[illegible] .89 1.84	3 .32 .59 .984 .87 1.79	4 .39 .74 .989 .93 1.87	5 .39 .53 .988 .83 1.77	2 .04 .34 .811 .63 .68	4 .47 .74 .992 .93 1.89	5 .79 .89 .998 .98 1.97	4 .44 .75 .990 .94 1.89	0 .05 .25 .856 .43 .71	4 .34 .59 .986 .87 1.80

TABLE 2 (continued)

Request	Total Number Retrieved	Word Stems Cosine	Thesaurus Cosine	Thesaurus Logical Cosine	Thesaurus Overlap	Thesaurus Titles Only Cosine	Thesaurus Stat. Phrases Queries Only Cosine	Thesaurus Stat. Phrases Cosine	Thesaurus Simulated Syntax Phrases Cosine	Thesaurus Hierarchy Up, Add. Cosine	Thesaurus Hierarchy Down Add. Cosine
IR-Indexing	6	4 .24 .41 .973 .68 1.54	4 .18 .45 .976 .73 1.62	2 .16 .40 .960 .66 1.46	6 .81 .88 .998 .97 1.96	2 .03 .31 .697 .49 1.02	4 .27 .45 .976 .73 1.62	5 .06 .63 .995 .96 1.93	3 .19 .56 .963 .82 1.64	3 .23 .42 .970 .69 1.54	6 .58 .74 .994 .92 1.89
Core Memory	7		3 .28 .61 .974 .84 1.71	2 .08 .38 .882 .59 1.08	 .18 .41 .953 .63 1.39	3 .19 .52 .957 .77 1.55	5 .31 .63 .977 .84 1.72	5 .29 .49 .976 .74 1.62	4 .28 .51 .974 .75 1.62	4 .22 .45 .963 .69 1.51	3 .25 .49 .970 .73 1.58
MIO-Counters	8	7 .76 .92 .997 .93 1.91	5 .90 .98 .999 .99 1.99	5 .33 .66 .977 .85 1.74	8 .79 .89 .996 .97 1.95	7 .13 .75 .928 .90 1.53	8 .89 .98 .999 .99 1.99	8 .95 .98 .999 .99 1.99	8 .95 .98 .999 .99 1.99	7 .69 .87 .995 .96 1.93	7 .67 .88 .994 .61 1.58

TABLE 2 (continued)

Requests	Total Number Relevant	Word Stems Cosine	Thesaurus Cosine	Thesaurus Logical Cosine	Thesaurus Overlap	Thesaurus Titles Only Cosine	Thesaurus Stat. Phrases Queries Only Cosine	Thesaurus Stat. Phrases Cosine	Thesaurus Simulated Syntax Phrases Cosine	Thesaurus Hierarchy Up, Add, Cosine	Thesaurus Hierarchy Down, Add, Cosine
M8-Storage	30	9 .42 .79 .943 .81 1.53	12 .46 .86 .952 .89 1.65	9 .28 .72 .893 .66 1.13	12 .45 .85 .950 .85 1.60	12 .30 .78 .902 .77 1.28	12 .46 .87 .952 .90 1.67	11 .44 .84 .946 .84 1.57	11 .36 .82 .928 .81 1.45	9 .31 .77 .906 .79 1.32	12 .49 .85 .956 .88 1.66

TABLE 2 (continued)

B. GENERAL LONG REQUESTS Requests	Total Number Relevant	Word Stems Cosine	Thesaurus Cosine	Thesaurus Logical Cosine	Thesaurus Overlap	Thesaurus Titles Only Cosine	Thesaurus Stat. Phrases Queries Only Cosine	Thesaurus Stat. Phrases Cosine	Thesaurus Simulated Syntax Phrases Cosine	Thesaurus Hierarchy Up, Add, Cosine	Thesaurus Hierarchy Down, Add, Cosine
Automata Phr.	9	6 .21 .61 .954 .80 1.57	5 .22 .63 .957 .82 1.60	6 .49 .74 .987 .89 1.83	5 .41 .72 .982 .92 1.79	4 .15 .56 .929 .76 1.40	5 .23 .63 .957 .82 1.60	7 .33 .73 .974 .89 1.76	7 .35 .74 .976 .89 1.77	3 .08 .45 .845 .62 1.85	5 .2 .62 .949 .81 1.55
Pattern Recg.	10	6 .14 .68 .917 .84 1.42	6 .35 .72 .974 .87 1.74	5 .16 .55 .926 .72 1.35	8 .29 .78 .965 .90 1.73	7 .10 .57 .872 .84 1.11	7 .32 .76 .978 .89 1.78	7 .38 .73 .978 .87 1.76	7 .40 .74 .979 .88 1.78	7 .45 .74 .983 .88 1.79	5 .14 .56 .914 .74 1.31
Differntl Eq.	16	13 .47 .88 .975 .94 1.81	12 .72 .92 .992 .96 1.92	7 .32 .70 .953 .80 1.56	10 .37 .80 .962 .88 1.69	10 .24 .78 .930 .86 1.52	12 .83 .95 .996 .97 1.95	14 .90 .98 .998 .99 1.98	14 .87 .97 .997 .97 1.97	9 .34 .78 .958 .87 1.66	12 .68 .90 .990 .95 1.90

TABLE 2 (continued)

Request	Total Number Relevant	Word Stems Cosine	Thesaurus Cosine	Thesaurus Logical Cosine	Thesaurus Overlap	Thesaurus Titles Only Cosine	Thesaurus Stat. Phrases Queries Only Cosine	Thesaurus Stat. Phrases Cosine	Thesaurus Simulated Syntax Phrases Cosine	Thesaurus Hierarchy Up, Add, Cosine	Thesaurus Hierarchy Down, Add, Cosine
Solstat Circ.	18	9 .46 .83 .971 .90 1.76	10 .41 .77 .964 .85 1.67	11 .37 .77 .959 .85 1.64	10 .53 .84 .978 .91 1.80	7 .17 .60 .879 .66 1.06	10 .40 .77 .964 .85 1.67	5 .33 .70 .951 .78 1.53	4 .22 .64 .915 .71 1.29	9 .35 .76 .954 .83 1.60	11 .36 .76 .956 .84 1.62
M9-Natlang	19	8 .16 .66 .884 .72 1.14	7 .19 .64 .881 .70 1.10	10 .28 .77 .842 .84 1.49	8 .22 .70 .908 .77 1.31	4 .10 .54 .770 .56 .41	7 .19 .65 .881 .71 1.11	11 .21 .77 .943 .87 1.58	9 .22 .71 .908 .79 1.33	5 .17 .61 .862 .65 .96	9 .24 .70 .916 .77 1.35
Comp Systems	21	4 .16 .64 .851 .68 .93	7 .18 .65 .868 .69 1.03	4 .13 .56 .806 .56 .58	7 .14 .57 .822 .58 .69	8 .12 .62 .787 .65 .59	7 .18 .65 .871 .70 1.05	6 .17 .64 .861 .68 .99	5 .13 .60 .815 .62 .69	7 .17 .64 .856 .68 .96	5 .16 .58 .845 .60 .83

TABLE 2 (continued)

	Requests Comps Assemb
Total Number Relevant	31
Word Stems Cosine	12 .43 .81 .916 .83 1.41
Thesaurus Cosine	15 .61 .95 .972 .96 1.82
Thesaurus Logical Cosine	12 .49 .86 .942 .88 1.59
Thesaurus Overlap	15 .48 .88 .954 .88 1.65
Thesaurus Titles Only Cosine	12 .30 .82 .898 .84 1.33
Thesaurus Stat. Phrases Queries Only Cosine	9 .37 .80 .927 .82 1.46
Thesaurus Stat. Phrases Cosine	12 .45 .86 .947 .85 1.59
Thesaurus Simulated Syntax Phrases Cosine	12 .29 .77 .897 .74 1.23
Thesaurus Hierarchy Up, Add, Cosine	15 .55 .90 .965 .90 1.73
Thesaurus Hierarchy Down, Add, Cosine	15 .60 .90 .971 .92 1.78

TABLE 2 (continued)

Method	Specific Requests			General Requests			All Requests		
	Normalized Recall	Normalized Precision	Over-all	Normalized Recall	Normalized Precision	Over-all	Normalized Recall	Normalized Precision	Over-all
Word Stems Cosine Corr.	.993	.90	1.86	.926	.82	1.45	.965	.86	1.66
Thesaurus Cosine Corr.	.991	.91	1.87	.945	.84	1.57	.969	.88	1.73
Thesaurus Logical Weights Cosine Corr.	.976	.85	1.73	.914	.78	1.40	.946	.82	1.57
Thesaurus Overlap Corr.	.987	.87	1.81	.940	.84	1.53	.965	.86	1.68
Thesaurus Titles Only Cosine Corr.	.905	.79	1.31	.871	.74	1.09	.889	.77	1.21
Thesaurus Stat. Phrases Queries Only Cosine Corr.	.992	.91	1.87	.941	.83	1.54	.968	.87	1.71
Thesaurus Stat. Phrase Cosine Corr.	.994	.93	1.90	.950	.85	1.60	.973	.89	1.76
Thesaurus Simulated Syntax Phrase Cosine Corr.	.988	.90	1.84	.927	.80	1.44	.959	.85	1.65

Averages of Normalized Evaluation Parameters

TABLE 3

Method	Specific Requests			General Requests			All Requests		
	Normalized Recall	Normalized Precision	Over-all	Normalized Recall	Normalized Precision	Over-all	Normalized Recall	Normalized Precision	Over-all
Thesaurus Hierarchy Up, Add Cosine Corr.	.972	.82	1.68	.916	.78	1.36	.946	.80	1.53
Thesaurus Hierarchy Down, Add, Cosine Corr.	.992	.87	1.83	.937	.81	1.50	.966	.84	1.67

TABLE 3 (continued)

A. SPECIFIC REQUESTS						
Request	Total Number Relevant	Thesaurus and Word Stems	Thesaurus and Stat. Phrases	Thesaurus and Hierarchy Down, Add	Thesaurus and Hierarchy Up, Add	Thesaurus, Word Stems and Statistical Phrases
Morse Code						
rank recall		.23	.60	.33	.25	.50
log. prec.		.28	.39	.33	.29	.43
norm. recall	2	.988	.998	.992	.989	.996
norm. prec.		.84	.90	.88	.85	.92
WTED. norm. rec. and norm. prec.		1.78	1.89	1.84	1.79	1.90
M2-Transmit						
		1.00	1.00	1.00	1.00	1.00
		1.00	1.00	1.00	1.00	1.00
	2	1.00	1.00	1.00	1.00	1.00
		1.00	1.00	1.00	1.00	1.00
		2.00	2.00	2.00	2.00	2.00
Crystal Calc.						
		1.00	1.00	.86	1.00	1.00
		1.00	1.00	.86	1.00	1.00
	3	1.00	1.00	.999	1.00	1.00
		1.00	1.00	.98	1.00	1.00
		2.00	2.00	1.98	2.00	2.00
M3-Inform						
		.50	.55	.60	.67	.50
		.53	.56	.62	.67	.53
	3	.995	.996	.997	.998	.995
		.90	.91	.93	.94	.90
		1.86	1.89	1.92	1.93	1.88
Random Numbs.						
		1.00	1.00	1.00	.91	1.00
		1.00	1.00	1.00	.93	1.00
	4	1.00	1.00	1.00	.999	1.00
		1.00	1.00	1.00	.99	1.00
		2.00	2.00	2.00	1.93	2.00
Analog-Digit						
		.38	.60	.38	.20	.47
		.65	.79	.63	.48	.72
	5	.988	.995	.987	.970	.991
		.90	.95	.89	.80	.92
		1.84	1.93	1.82	1.65	1.88

Combined Method Retrieval Results for Individual Requests

TABLE 4

Request	Total Number Relevant	Thesaurus and Word Stems	Thesaurus and Stat. Phrases	Thesaurus and Hierarchy Down, Add	Thesaurus and Hierarchy Up, Add	Thesaurus and Word Stems, Statistical Phrases
IR-Indexing	6	.23 .43 .970 .70 1.55	.48 .68 .990 .89 1.84	.43 .64 .988 .88 1.82	.24 .43 .972 .71 1.57	.44 .58 .989 .84 1.78
Core Memory	7		.30 .54 .976 .78 1.66	.30 .56 .976 .80 1.68	.25 .55 .969 .79 1.64	
M10-Counters	8	.90 .96 .999 .99 1.98	.95 .98 .999 .99 1.99	.84 .93 .998 .98 1.97	.90 .95 .999 .99 1.98	.90 .96 .999 .99 1.98
M8-Storage	30	.54 .87 .964 .87 1.70	.45 .85 .949 .86 1.60	.48 .86 .956 .86 1.64	.40 .82 .939 .82 1.51	.54 .87 .965 .88 1.70

TABLE 4 (continued)

B. GENERAL REQUESTS Request	Total Number Relevant	Thesaurus and Word Stems	Thesaurus and Stat. Phrases	Thesaurus and Hierarchy Down, Add	Thesaurus and Hierarchy Up, Add	Thesaurus and Word Stems, Statistical Phrases
Automata Phr.	9	.31 .69 .971 .86 1.72	.30 .74 .970 .89 1.74	.21 .62 .952 .81 1.57	.21 .65 .952 .83 1.59	.32 .74 .973 .89 1.76
Pattern Recg.	10	.35 .74 .974 .88 1.75	.34 .71 .973 .87 1.73	.22 .58 .949 .76 1.51	.37 .73 .977 .87 1.76	.31 .71 .969 .86 1.71
Differntl Eq.	16	.79 .94 .994 .97 1.94	.89 .96 .997 .98 1.97	.62 .88 .987 .94 1.87	.65 .88 .988 .94 1.88	.92 .98 .998 .99 1.98
Solstat Circ.	18	.37 .74 .959 .82 1.61	.37 .74 .958 .82 1.61	.39 .77 .962 .85 1.66	.37 .76 .959 .84 1.63	.37 .72 .958 .80 1.60
M9-Natlang	19	.17 .65 .877 .72 1.11	.29 .74 .937 .82 1.50	.22 .66 .908 .73 1.27	.16 .60 .860 .66 .98	

TABLE 4 (continued)

Request	Total Number Relevant	Thesaurus and Word Stems	Thesaurus and Stat. Phrases	Thesaurus and Hierarchy Down, Add	Thesaurus and Hierarchy Up, Add	Thesaurus and Word Stems, Statistical Phrases
Comp. Systems	21	.17 .65 .861 .69 1.00	.19 .66 .875 .71 1.09	.16 .62 .854 .65 .92	.18 .65 .865 .70 1.02	
Comps. Assemb.	31	.55 .89 .965 .89 1.71	.52 .89 .961 .90 1.70	.58 .90 .969 .90 1.74	.57 .91 .968 .91 1.75	.53 .89 .962 .89 1.70

TABLE 4 (continued)

Method	Specific Requests			General Requests			All Requests		
	Normalized Recall	Normalized Precision	Over-all	Normalized Recall	Normalized Precision	Over-all	Normalized Recall	Normalized Precision	Over-all
Thesaurus and Word Stems	.993	.92	1.88	.946	.84	1.57	.970	.88	1.73
Thesaurus and Stat. Phrases	.995	.94	1.91	.953	.86	1.62	.976	.90	1.77
Thesaurus and Hierarchy Down, Add	.993	.93	1.89	.942	.81	1.52	.969	.87	1.72
Thesaurus and Hierarchy Up, Add	.988	.90	1.83	.939	.83	1.52	.965	.87	1.68
Thesaurus and Word Stems, Stat. Phrases	.996	.95	1.93	.971	.89	1.74	.978	.92	1.85

Averages of Normalized Evaluation Parameters for Combined Methods

TABLE 5

Tables 2 and 3 deal with the performance characteristics of individual processing methods. To investigate the performance which might be obtained by using pairs or triples of different analysis techniques for retrieval purposes, a program was written which merges the retrieval lists for a given request over a number of processing methods. The merged list is then treated as a standard retrieval list, and all of the evaluation measures developed for individual methods may be applied to the merged list. An investigation of the performance of the merged methods has not been completed. However, Table 4 contains some typical results of merging the output for different processing methods on a request-by-request basis. Table 5 presents averages of the evaluation parameters over specific, general, and all requests for each of the merged processes.