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Content-based Document Recommender System for Aerospace Grey Literature: Experimental Testing and User Opinion Survey

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ABSTRACT

The study aims to test content-based document recommender system (CODORS) with sample data to retrieve most relevant technical documents without necessarily matching title terms and closely related to particular search term(s). The CODORS system was put open for users to search and obtain recommendations with weighted relevance ranking and also allowed to compare the results obtained through general OPAC search engine for the same keywords. Based on the findings of the experimental testing and evaluation, some conclusions have been drawn:The results exhibited that the CODORS search provided many more relevant documents and increased the recall value as compared to general OPAC search and also revealed documents that were retrieved for a given query through OPAC search appeared at different places-top, middle or end of the ranked list of documents - generated through the CODORS search for the same query.

Keywords: Recommender systems, content-based document recommender system, CODORS, information retrieval, document retrieval

1. THE RESEARCH PROBLEM

The need for enhancing the recall value of the results retrieved motivated the researcher to search for a technique that would retrieve more documents for a given query, particularly grey literature on aerospace. Some retrieval models generally rank retrieved documents as relevant to the query according to some criteria and such models are called as ranking models[1]. The study of advances made in IR systems, more particularly retrieval models such as Boolean model, vector space model, and probabilistic retrieval models, showed not only the possibility of retrieving more relevant documents for a given query, but also ranking of these documents so as to facilitate the user to select the relevant documents based on the objectivity. It also provided a cut-off point in case if large number of relevant documents were retrieved. With this aim in mind, the authors chose the research problem entitled, "Designing Content-based Document Recommender System for aerospace grey literature".

The authors, hence, developed a test-bed database of grey literature on aerospace engineering using 'Dialog OnDisc Aerospace Database' brought out by American Institute of Aeronautics and Astronautics (AIAA) for this purpose. Further, the authors developed a recommender system known as Content-based Document Recommender System (CODORS)[2] using Boolean operators. The recommender system so developed was put to test using the above database and results of CODORS searches were compared with the retrieved output of the normal OPAC searches. The major issues of concern in designing this recommender system were: to increase the search capability and to get ranked list of documents retrieved by automatically assigning weightage to each document retrieved.

2. OBJECTIVES OF THE STUDY

The objectives of the study are:

- To understand and to assess the capability of general OPAC to retrieve grey literature relevant to scientists working in the field of aerospace engineering and allied sciences.
- To design CODORS using first order descriptors in aerospace engineering and allied sciences based

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on individual user search words (profiles) to facilitate easy access to and optimum utilisation of relevant information in the form of grey literature.

3. HYPOTHESIS

Although the objectives of the study are clear, there were chances that the study may deviate from the track as the research progresses. Hence, it was necessary to have a hypothesis running through the objectives. For the present study, the following hypothesis was formulated:

H+: Use of CODORS as compared to general OPAC searches results in retrieving comprehensive, highly relevant and ranked documents in the field of aerospace engineering and allied sciences.

4. METHODOLOGY OF THE STUDY

The study adopted was the experimental testing and user opinion surveys. It began with the development of bibliographic database of papers of conference proceedings relevant in the field of aerospace engineering and allied sciences. Titles of the conference papers and associated descriptors were considered essential for the study. As the efficiency and accuracy of the system to be developed depended solely on the suitable descriptors representing the thought content of the documents, the descriptors assigned in the source, i.e., Dialog OnDisc Aerospace Database were used as these descriptors were assigned using NASA thesaurus. The next step was the development of CODORS using 'first-order descriptors'. The steps involved in the development of CODORS are described.

S1: Extraction of individual search words (terms) entered by the users.

S2: Retrieval of titles of all documents having all the search words (terms) entered by the users.

S3: Retrieval of all descriptors that are assigned to all documents retrieved at step S2.

S4: Formulation of weighted vector of descriptors as it is the base of user profile. The elements of the vector are termed as 'first-order descriptors'. Weights for the descriptors are calculated based on number of occurrences of individual descriptors with reference to total number of descriptors retrieved at step S3.

S5: Mining of all documents titles from the database, which are having at least any one of the 'First Order Descriptors' retrieved at step S3.

S6: With the help of matching descriptors, calculation of the percentage weightage of each document retrived at step S5.

S7: Calculation of "Boosting Factor" with the help of highest ranked document from CODORS results and adding to every document in the results.

S8: Displaying the documents retrieved at Step S7 on the basis of decreasing order of relevance.

5. SYSTEM TESTING WITH SAMPLE SEARCH QUERIES

Exercising formal testing of information retrieval systems was carried out initially in Cranfield experiments in early 1960s. The aim of Cranfield research was to find ways to improve the retrieval effectiveness of IR systems through better indexing languages and methods[3]. For performance comparisons, quantitative measures used in the Cranfield II experiments were recall and precision, which are the derivative of the concept of relevance[4]. A series of IR experiments were conducted on the SMART system by Gerald Salton[5,6]. A series of experiments, known as TREC (Text TEtrieval Conference), were started in 1992 and were considered as real experimental approach to information retrieval evaluation.

Having designed the CODORS recommender system, it was put to test. As many as 124 search tests were conducted using different key terms ranging from broader to narrower subject fields in the area of aerospace engineering. The hit results of general OPAC searches and CODORS searches were studied, tabulated, and compared to assess the usefulness of CODORS. Detailed search queries and results obtained using normal OPAC and CODORS are shown in *Appendix 1*.

6. SUMMARY OF FINDINGS WITH SAMPLE SEARCH QUERIES

The findings of the experiments conducted on the test database using CODORS recommender system in actual environment are summarised here under:

(i) General OPAC search could retrieve documents ranging between 2 to 10 for a given query. The search under CODORS system retrieved 10-500 documents and even more for a given query. It, however, depends on the subject area of the query. That means the recall value of the searches under CODORS is found to be much greater compared to that of general OPAC searches.

(ii) The CODORS searches provided ranking of all the documents retrieved and this ranking is based on the weightages of the document relevance for a given query.

(iii) In the ranking order, majority of the documents retrieved from the general OPAC are normally placed either somewhere in the top, middle or in the end of the ranked list of documents which means many more relevant documents are left un-retrieved, in case of simple OPAC search.

7. OPINION SURVEY OF USERS ON CODORS

The questionnaire is an importa survey technique for gathering data from users during recommender system evaluation experiments. Questionnaire is structured research instrument which is used to collect research data in a face-to-face interview, self-completion survey, telephone interview or Web survey. It consists of a series of questions, which may be in form, on interview schedule on paper, or on a webpage[7].

The system was thrown open to the users to enable them to use CODORS searches and thereby test the usability of this recommender system in actual environment. The scientists were provided URLs of both general OPAC and CODORS on Intranet of Defence Research and Development Laboratory (DRDL) and requested to search their required information relating to grey literature. To assess and confirm the usability of the recommender system-CODORS-in actual environment an opinion survey of users was conducted through structured questionnaire. As many as 27 questions relating to various aspects of information search including use of OPAC and CODORS were provided in the questionnaire (*Appendix 2*).

The questionnaire comprised closed questions that provide a fixed set of responses with which users must respond such as more relevant, most relevant and not relevant, etc. The questionnaire was distributed to 150 scientists and technocrats who are the regular users of the library. All the 150 users responded to the questionnaire. These questionnaires have been tabulated, analysed and results have been reported in succeeding sections.

8. ANALYSIS OF OPINION SURVEY

8.1 Familiarity of Users with Online Public Access Catalogue

Users were asked to furnish to what extent they are familiar with Online Public Access Catalogue (OPAC). Table 1 shows users opinion on their familiarity with OPAC of libraries. Out of 150 users, 78 (52 per cent) respondents mentioned that they are familiar with OPACs, 71 (47.33per cent) respondents said that they are very familiar with OPACs and 1 (00.67per cent) respondent stated that he is not very familiar with OPACs.

Table 1. Familiarity with OPAC

Opinion	No. of respondents	Percentage
Not very familiar	1	00.67
Familiar	78	52.00
Very familiar	71	47.33

8.2 Relevance of Documents Retrieved Using Simple OPAC

Opinions of users about the relevance of documents retrieved through OPAC searches were collected under 5 options as shown in Table 2. Table 2 depicts that 86 (57.33 per cent) respondents mentioned that the results are relevant between 50-74 per cent, 60 (40 per cent) respondents said that the results are relevant between 75-99 per cent and 4 (2.67 per cent) respondents stated that the results are relevant between 25-49 per cent. No user mentioned that the results were 100 per cent relevant, and they were less than 25 per cent relevant.

Table 2. Relevance of documents retrieved using simple OPAC

Opinion	No. of respondents	Percentage
100 per cent relevant	0	00.00
Between 75-99 per cent relevant	60	40.00
Between 50-74 per cent relevant	86	57.33
Between 25-49 per cent relevant	4	02.67
Less than 25 per cent relevant	0	00.00

8.3 Display of Documents with Relevance Ranking in OPAC Search

To the question whether results of general OPAC searches are displayed in ranked order giving their weightages of relevance, all 150 (100.00per cent) respondents answered that the search results were not displayed with relevance ranking.

8.4 Retrieval of Results in OPAC Searches where Key Terms did not Match Titles

Users were asked to furnish their opinion on results of OPAC searches in cases where the key term keyed in by them did not match the title of document. All 150 (100 per cent) respondents answered that there were no hits and the search results were not displayed.

8.5 Users' Knowledge of Filtering Systems for Filtering Relevant Information

To a question about the knowledge of filtering systems 125 (83.33 per cent) respondents expressed that they were not aware of any filtering system for filtering relevant information and 25 (16.67 per cent) respondents said that they were aware of filtering systems. Table 3 depicts the same.

Table 3. Knowledge of filtering systems for filtering relevant information

Opinion	No. of respondents	Percentage
Aware	25	16.67
Not aware	125	83.33

8.6 Users' Knowledge about Thesaurus and its Importance in Information Retrieval

Table 4 depicts that 119 (79.33 per cent) respondents were not aware of thesaurus and its importance in information retrieval. Thirty-one (20.67 per cent) respondents were aware of the importance of the thesaurus.

Table 4. Knowledge about thesaurus and its importance in information retrieval

Opinion	No. of respondents	Percentage
Yes	31	20.67
No	119	79.33

8.7 Users' Knowledge about Concept-based Searching

Table 5 shows that 120 (80 per cent) respondents were not having the knowledge about concept-based searching and 30 (20 per cent) respondents were having the knowledge about concept-based searching.

Table 5. Knowledge about concept-based searching

Opinion	No. of respondents	Percentage
Yes	30	20
No	120	80

8.8 Users' Knowledge of Recommender Systems for Identifying Relevant Information

To a question about the knowledge of recommender systems for identifying relevant information, all 150 (100 per cent) respondents replied that they were aware of recommender system.

8.9 Users' Awareness of Content-based Document Recommender System

To a question whether the users are aware of CODORS, all 150 (100 per cent) respondents replied positively and said that they were aware of CODORS.

8.10 Usage of CODORS for Searching Required Information by the Users

Users were asked whether they use CODORS for searching required information. All 150 (100 per cent) respondents replied positively and said they were using CODORS for searching information of their requirement.

8.11 Usage Frequency of CODORS for Searching Required Information

Opinion on usage frequency of CODORS was collected from the respondents. Seventy-seven (51.33 per cent) respondents used CODORS 'once in a week', followed by 39 (26 per cent) respondents who used it twice in a week', 19 (12.67 per cent) respondents who used it 'once in 2 weeks', and remaining 11 (7.33 per cent) respondents who used it rarely (Table 6).

Table 6. Usage frequency of CODORS for searching required information

Opinion	No. of respondents	Percentage
Daily	0	00.00
Thrice in a week	4	02.67
Twice in a week	39	26.00
Once in a week	77	51.33
Once in 2 weeks	19	12.67
Rarely	8	05.33
Not responded	3	02.00

8.12 Usefulness of CODORS Results

Table 7 depicts users' opinion about the usefulness of CODORS results. Table 8 shows that 148 out of 150 representing 98.67 per cent of the total found the results useful and none have found them not useful. However, 2 (1.33 per cent) respondents have not responded to the query.

Table 7. Usefulness of CODORS results

Opinion	No. of respondents	Percentage
Useful	148	98.67
Not useful	0	00.00
Not responded	2	01.33

8.13 Expected Number of Hits from CODORS Search

Users were asked whether they had expected specific number of results before they completed their search through CODORS and if so whether the results obtained were more than the expectation and otherwise less. Table 8 reveals that 134 (89.33 per cent) respondents got more results than they expected, 16 (10.67 per cent) respondents got expected number of results. But none of the user experienced hit results less than expectation.

Table 8. Expected number of hits from CODORS search

Opinion	No. of respondents	Percentage
Expected	16	10.67
More than expected	134	89.33
Less than expected	0	00.00

8.14 Relevance of CODORS Search Results

Respondents were asked to furnish their opinion about the relevance of the results of CODORS search. Table 9 depicts that for 72 (48.00 per cent) respondents the CODORS search results are relevant 'between 51-75 per cent', for 66 (44.00 per cent) respondents the results were relevant 'between 76-99 per cent', for 11 (7.33 per cent) respondents the results were relevant ' between 26-50 per cent' and for 1 (0.67 per cent) respondent the results were 100 per cent relevant. None of the respondent expressed that results are below 25 per cent and as well not relevant.

Table 9. Relevance of CODORS search results

Opinion	No. of respondents	Percentage
Not relevant	0	00.00
< 25 % relevant	0	00.00
Between 26-50 % relevant	11	07.33
Between 51-75 % relevant	72	48.00
Between 76-99 % relevant	66	44.00

8.15 Ease of use in Searching CODORS

Users were asked to state whether searching information through CODORS is easy and if so to what extent? Table 10 depicts that 123 (82.00 per cent) respondents expressed that searching for information using CODORS is 'very easy', followed by 22 (14.67 per cent) respondents who said that it is 'moderately easy', 5 (3.33 per cent) respondents who opined that it is 'easy to some extent', and no respondent who mentioned 'Not easy' option.

Table 10. Ease of use in searching CODORS

Opinion	No. of respondents	Percentage
Not easy	0	00.00
Easy to some extent	5	03.33
Moderately easy	22	14.67
Very easy	123	82.00

8.16 Frustration Using CODORS by the Users

Users were asked to give their opinion if they got frustrated while using CODORS. There were 148 respondents representing 98.67 per cent of the total who opined that they were not frustrated. Only 2 (1.33 per cent) respondents expressed that they were frustrated (Table 11).

Table 11. Frustration while using CODORS

Opinion	No. of respondents	Percentage
Yes	2	01.33
No	148	98.67

8.17 Satisfaction about Display of Relevance Ranking of CODORS Search Results

When asked the users whether they were satisfied with the display of relevance ranking of CODORS results, all 150 (100 per cent) expressed positively.

8.18 Usefulness of CODORS for Finding Relevant Documents on a Particular Subject of Interest

Opinion expressed by the respondents on usefulness of CODORS for finding relevant documents on a particular subject of interest revealed that all 150 (100 per cent) respondents were positive opined that the CODORS is useful for finding relevant documents on a particular subject of interest.

8.19 Comprehensiveness of CODORS Results on a Particular Subject of Interest

All 150 (100) respondents expressed that CODORS search on a particular subject of interest provided them comprehensive search output.

8.20 Results of CODORS Searches with Key Terms that did not Match Title Terms

Users were asked to furnish whether they experienced hits in CODORS searches where in the key terms they used did not match with title of the document. One hundred forty-five (96.67 per cent) respondents stated they experienced hit results though key terms did not match with title of the documents. However, 5 (3.33 per cent) respondents expressed that they did not experienced hit results wherever the key terms did not match with terms in the title (Table 12).

Table 12. In CODORS results, key terms that did not match title terms

Opinion	No. of respondents	Percentage
Obtained hit results	145	96.67
Did not obtained hit results	5	03.33

8.21 Percentage of Success in CODORS Results when Key Terms did not Match Title Terms

The authors collected the opinion under five options about the percentage of success in CODORS searches when key terms did not match title terms and tabulated the same. Table 13 revealed that 93 (62.00 per cent) respondents rated the success between 50-74 per cent, 35 (23.33 per cent) respondents rated the success between 75-99 per cent, and 22 (14.67 per cent) respondents rated the success between 25-49 per cent. None of the respondent has rated the success below 25 per cent and as well 100 per cent.

Table 13. Percentage of success in CODORS results when key terms did not match title terms

Opinion	No. of respondents	Percentage
Less than 25 % success	0	00.00
Between 25-49 % success	22	14.67
Between 50-74 % success	93	62.00
Between 75-99 % success	35	23.33
100 % success	0	00.00

8.22 Searching CODORS for Document of Highest Relevance

For a question whether they searched for results in CODORS keeping in mind a document of highest relevance, all (150; 100 per cent) respondents expressed positively.

8.23 Retrieving More Documents in Ranked Order in Addition to the Document of Interest.

User's opinion was sought on the retrieval of more relevant references in ranked order in addition to one that they considered has highest relevance all 150 (100.00 per cent) respondents opined positively.

8.24 Retrieval of Documents by CODORS Ranked Above the One Considered More Relevant

Users were also asked if they had experienced more number of hits than that of the one they had considered most relevant, did they found such documents still better relevant. Table 14 shows that 148 respondents out of total 150 representing 98.67 per cent expressed positively and said retrieval of documents by CODORS were ranked above the one they considered most relevant and only 2 (1.33 per cent) respondents mentioned that retrieval of documents by CODORS were not ranked above the one they considered most relevant.

Table 14. Retrieval of documents by CODORS ranked above the one considered more relevant

Opinion	No. of respondents	Percentage
Yes	148	98.67
No	2	01.33

8.25 Relevance of Recommendations by CODORS Ranked above the Document the User Considered Relevant

User were asked to furnish their opinion on how relevant were the documents that were displayed by CODOR search and ranked above the document that the user considered most relevant. Table 15 presents that 89 (59.33 per cent) respondents opined that the CODORS recommendations ranked above the one considered relevant were more relevant and 59 (39.33 per cent) respondents opined that CODORS recommendations were most relevant and 2 (1.33 per cent) respondents mentioned that the CODORS recommendations were not better relevant.

Table 15. Relevance of CODORS recommendations ranked above the document the user considered relevant

Opinion	No. of respondents	Percentage
Most relevant	59	39.33
More relevant	89	59.33
Not relevant	2	01.33

9. SUMMARY OF FINDINGS USING OPINION SURVEY

The findings of the survey sought by the users about the usability of CODORS recommender system in actual working environment are summarised below:

(i) All (150; 100 per cent) aerospace users of RDL are aware of recommender systems and particularly CODORS.

(ii) All (150; 100 per cent) users use CODORS to search information of their requirement.

(iii) Out of 150 users, who use CODORS, 77 (51.33 per cent) respondents use it once in a week, 39 (26 per cent) use it twice in a week, 19 (12.67 per cent) use it thrice in a week, 4 (2.67 per cent) use it once in two weeks and 8 (5.33 per cent) users use it rarely. Remaining 3 (2 per cent) users have not responded.

(iv) One hundred forty-eight out of 150 representing 98.67 per cent of the total respondents opined that they did found useful and interesting documents through CODORS search and remaining 2 (1.33 per cent) users have not responded to the query.

(v) One hundred thirty-four out of 150 representing 89.33 per cent of the total respondents have expressed that the hit results from the CODORS search were more than they expected and for remaining 16 (10.67 per cent) respondents the hit results were as expected by them.

(vi) For 72 respondents representing 48 per cent of the total, the retrieved documents were relevant between 51-75 per cent, for 66 (44 per cent) users the relevancy of documents ranging between 76-99 per cent, for 11 (7.33 per cent) users the relevancy was between 26-50 per cent and for 1 (0.67 per cent) user the relevancy of documents retrieved was 100 per cent.

(vii) One hundred twenty-three users representing 82 per cent of the total are of the opinion that the CODORS search is very easy as against 22 (14.67 per cent) users who opined that it is moderately easy and for 5 (3.33 per cent) users, CODORS search is not easy.

(viii) One hundred forty-eight representing 98.67 per cent of the total users expressed that they never felt frustrated while using CODORS as against 2 (1.33 per cent) users who felt frustrated.

(ix) All (100 per cent) users have been convinced with display of percentage relevance ranking of the results of CODORS search.

(x) All (100 per cent) users expressed that CODORS is useful for finding relevant documents on the subject of their interest.

(xi) All (100 per cent) users opined that CODORS results on the subject of their interest were comprehensive.

(xii) One hundred forty-five users representing 96.67 per cent of the total experienced that they could get hit results from CODORS search through the key terms they used which did not match with terms in the titles of documents retrieved. The remaining 5 (3.33 per cent) did not experience this situation.

(xiii) The percentage of success rate of retrieved results from CODORS was 50-74 per cent for 93 (62 per cent) users, 75-99 per cent for 35 (23.33 per cent) users and between 25-49 per cent for 22 (14.67 per cent) users.

(xiv) All users (100 per cent) searched information using CODORS keeping in mind its highest relevance. In all such cases all (100 per cent) users experienced search output of not only those documents in mind but also additional documents.

(xv) One hundred forty-eight out of 150, representing 98.67 per cent of the total respondents expressed that they obtained documents ranked higher than that of the one they had considered more relevant. Among these 148 users who obtained higher ranking documents, 89 (59.33 per cent) expressed that such documents were more relevant, 59 (39.33 per cent) said they were most relevant and only 2 (1.33 per cent) expressed that there was not much difference in the relevance between the documents ranked higher and the document they considered most relevant.

10. CONCLUSIONS

Designed CODORS converts the terms expressed by the user in natural language automatically into subject descriptors, carry on search, rank documents and retrieve. The document ranking is automatically done by the system on the basis of weightages calculated based on the occurrences of number of subject descriptors, which are assigned to each title of the document in the collection. The results are sorted on relative relevance ranking and are presented to the user for maximum utilization of technical resources that are otherwise hidden in the database collection.

The CODORS was put to test by conducting repeated searches using variety of descriptors/key terms relating to general and specialized subject areas in the field of aerospace engineering. The results exhibited that the CODORS search provided many more relevant documents and increased the recall value as compared to general OPAC search. It also revealed those documents that were retrieved for a given query through OPAC search appeared at different places - top, middle, or end of the ranked list of documents generated through the CODORS search for the same query. The system having put for use in the actual environment revealed the encouraging results. The results of the opinion survey covering 150 regular users of DRDL library correlated with the results of the experimental test and found highest usability as it provided not only expected relevant documents but also more relevant documents giving ranked weightages.

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Comparison of Search Results Pertaining to General OPAC and CODORS

Search Terms	NOR	CODORS Recommendations														
		NDE	DEW	BF	95 - 100%	90-95%	85-90%	80-85%	75-80%	70-75%	65-70%	60-65%	55-60%	50-55%	0-50%	TR
ROTOR AERODYNAMICS MANEUVERING	2	16	6.25	31.25	1 (1)	0	0	0	0	0	7	17 (1)	85	0	22905	23015
ADVANCED HYPERSONIC AIRCRAFT	2	16	6.25	43.75	1 (1)	0	1 (1)	0	0	0	1	26	286	0	6300	6615
NDT RELIABILITY	2	18	5.56	33.33	1 (1)	0	0	0	6	9	7 (1)	11	59	0	15658	15751
VHDL MODELING	2	15	6.67	40.00	1 (1)	0	0	0	2 (1)	3	27	0	326	3291	27489	31139
SEMICONDUCTOR X-RAY DETECTORS ASTRONOMY	2	15	6.67	33.33	1 (1)	0	0	0	0	3	5 (1)	0	16	104	11795	11924
COMPUTATIONAL FLUID DYNAMICS MISSILE	3	37	2.70	54.05	1 (1)	0	0	4 (2)	7	53	145	1953	29524	0	0	31687
PHASED ANTENNA ARRAY SATELLITES	3	23	4.35	60.87	3 (2)	3 (1)	12	38	112	448	12014	0	0	0	0	12630
HYPERSONIC VEHICLE MANEUVERING	3	29	3.45	48.28	1 (1)	0	0	0	1 (1)	0	4 (1)	9	1344	18589	0	19948
FLEXIBLE MANUFACTURING SYSTEMS	3	22	4.55	59.09	1 (1)	1 (1)	2 (1)	5	34	325	2845	25310	0	0	0	28523
ACTIVE VIBRATIONAL CONTROL	3	24	4.17	62.50	2 (2)	4 (1)	22	110	421	5137	20715	0	0	0	0	26411
NDT CFRP	3	22	4.55	63.64	2 (2)	4 (1)	5	44	241	1395	12430	0	0	0	0	14121
COPPER CORROSION	3	26	3.85	57.69	2 (2)	0	0	1	11 (1)	49	2361	9757	0	0	0	12181

Note: NOR=Number of OPAC results; NDE=Number of descriptors; DEW=Descriptor weight; BF=Boosting factor; TR=Total CODORS recommendations; Values with in brackets indicate number of OPAC results

Search Terms	NOR	CODORS Recommendations														
		NDE	DEW	BF	95 - 100%	90-95%	85-90%	80-85%	75-80%	70-75%	65-70%	60-65%	55-60%	50-55%	0-50%	TR
SPACE SHUTTLE SOFTWARE RELIABILITY	3	26	3.85	57.69	1 (1)	0	1 (1)	2 (1)	12	51	1697	12414	0	0	0	14178
SHOCK TUNNEL SCRAMJET	3	40	2.5	57.50	1 (1)	1 (1)	1	0	1 (1)	4	100	2719	18574	0	0	21401
MISSILE SYSTEM INTEGRATION	4	43	2.33	62.79	1 (1)	0	2 (1)	2 (1)	10 (1)	92	37737	0	0	0	0	37844
PROPULSION TRANSPORTATION SYSTEMS	4	43	2.33	67.44	1 (1)	2 (2)	3	23 (1)	200	3029	18033	0	0	0	0	21291
NUMERICAL SIMULATION MISSILE	4	37	2.70	70.27	2 (2)	1 (1)	8 (1)	229	3868	18032	0	0	0	0	0	22140
NONLINEAR CONTROL AUTOPILOT	4	39	2.56	71.79	2 (2)	5 (2)	26	529	4912	11503	0	0	0	0	0	16977
OPTIMAL DISTURBANCE REJECTION	4	34	2.94	64.71	1 (1)	2 (1)	45 (1)	138 (1)	1502	5550	11331	0	0	0	0	18569
ELLIPTICAL ANTENNA	4	27	3.70	70.37	2 (2)	3 (1)	81 (1)	215	894	17040	0	0	0	0	0	18235
ADAPTIVE ANTENNA ARRAY GPS	4	34	2.94	70.59	3 (3)	0	37 (1)	139	3391	19535	0	0	0	0	0	23105
AIRCRAFT ATTITUDE DETERMINATION	4	35	2.86	74.29	5 (4)	5	144	706	32051	0	0	0	0	0	0	32911
KALMAN FILTERING TARGET TRACKING	4	34	2.94	67.65	2 (2)	0	9 (2)	45	1084	25411	0	0	0	0	0	26551
COMPUTATIONAL FLUID DYNAMICS AERODYNAMICS	4	39	2.56	69.23	1 (1)	2 (2)	8 (1)	112	1592	19366	0	0	0	0	0	21081

Search Terms	NOR	CODORS Recommendations													
		NDE	DEW	BF	95 - 100%	90-95%	85-90%	80-85%	75-80%	70-75%	65-70%	60-65%	55-60%	50-55%	0-50%	TR
COMPUTATIONAL FLUID DYNAMICS COMPUTERS	4	38	2.63	68.42	1 (1)	2 (2)	2 (1)	69	1078	25922	0	0	0	0	0	27074
COMPUTED TOMOGRAPHY AIRCRAFT	4	42	2.38	69.05	2 (2)	2 (1)	11 (1)	72	885	19158	0	0	0	0	0	20130
TRUSS STRUCTURES GENETIC ALGORITHM	4	32	3.13	68.75	2 (2)	1	6 (2)	114	916	40578	0	0	0	0	0	41617
BACK-TO-TURN MISSILE AUTOPILOT DESIGN	4	38	2.63	68.42	2 (2)	0	6 (2)	195	2532	22493	0	0	0	0	0	25228
THRUST VECTOR CONTROL AIRCRAFT	4	40	2.50	60.00	1 (1)	0	0	1 (1)	17 (2)	75	911	32584	0	0	0	33589
SOLID ROCKET MOTOR PROPELLANT SIMULATION	4	40	2.50	70.00	2 (2)	0	7 (2)	164	1717	22957	0	0	0	0	0	24847
COMPOSITE ROCKET PROPELLANTS	5	49	2.04	73.47	1 (1)	2 (2)	12 (2)	90	14484	0	0	0	0	0	0	14589
AIR BREATHING DYNAMICS	5	59	1.70	67.80	1 (1)	0	1 (1)	4 (3)	90	8115	23048	0	0	0	0	31259
COMMUNICATION SATELLITES ANTENNA	5	39	2.56	71.79	1 (1)	3 (2)	23 (2)	175	2748	16733	0	0	0	0	0	19683
HYDROGEN PROPELLANTS	5	53	1.89	62.26	1 (1)	0	0	0	6 (4)	24	1735	13536	0	0	0	15302
COMBUSTION MECHANISM PROPELLANTS	5	47	2.13	70.21	1 (1)	2 (1)	33 (2)	145 (1)	530	17102	0	0	0	0	0	17813
SUPERSONIC AIRCRAFT TRANSPORT RESEARCH	5	61	1.64	72.13	2 (2)	1 (1)	10 (2)	184	5587	11941	0	0	0	0	0	17725

Search Terms	NOR	CODORS Recommendations														
		NDE	DEW	BF	95 - 100%	90- 95%	85- 90%	80- 85%	75- 80%	70- 75%	65- 70%	60- 65%	55- 60%	50- 55%	0- 50%	TR
OPTIMIZATION COMPUTATIONAL FLUID DYNAMICS	5	43	2.33	76.74	4 (3)	22 (2)	476	5329	21242	0	0	0	0	0	0	27073
BOUNDARY LAYER COMPUTATIONAL FLUID DYNAMICS	5	49	2.04	77.55	6 (5)	19	956	6687	23045	0	0	0	0	0	0	30713
BALLISTIC MISSILE INTERCEPTION	5	45	2.22	75.56	4 (4)	3	21 (1)	522	26646	0	0	0	0	0	0	27196
CFD SOLVER	5	43	2.33	72.09	2 (2)	4	123 (3)	1076	4954	15514	0	0	0	0	0	21673
CLUSTER COMPUTING	5	41	2.44	78.05	8 (5)	55	1086	30049	0	0	0	0	0	0	0	31198
AIRCRAFT FLIGHT CONTROL SIMULATION	5	47	2.13	74.47	2 (2)	7 (2)	168 (1)	2039	31131	0	0	0	0	0	0	33347
MULTIVARIABLE ACTIVE CONTROL	5	50	2.00	76.00	3 (3)	9 (2)	557	3856	31257	0	0	0	0	0	0	35682
NDT AIRCRAFT	5	39	2.56	76.92	4 (4)	7	184 (1)	3486	15506	0	0	0	0	0	0	19187
HWIL SIMULATION MISSILE	5	42	2.38	76.19	4 (4)	10 (1)	107	2589	20118	0	0	0	0	0	0	22828
HWIL SIMULATION SYSTEMS	5	36	2.78	72.22	1 (1)	2 (2)	22 (2)	394	2422	23745	0	0	0	0	0	26586
HELLFIRE MISSILE	5	53	1.89	69.81	1 (1)	1 (1)	4 (2)	12 (1)	649	36691	0	0	0	0	0	37358
C4I	8	71	1.41	77.46	1 (1)	4 (3)	34 (2)	9476 (2)	38492	0	0	0	0	0	0	48007

Search Terms	NOR	CODORS Recommendations													
		NDE	DEW	BF	95 - 100%	90-95%	85-90%	80-85%	75-80%	70-75%	65-70%	60-65%	55-60%	50-55%	0-50%	TR
BATTERIES AIRCRAFT APPLICATIONS	5	39	2.56	74.36	4 (3)	1 (1)	48	520 (1)	14971	0	0	0	0	0	0	15544
ACCELERATION CONTROL DESIGN	5	43	2.33	72.09	1 (1)	3 (2)	21 (2)	766	8995	28706	0	0	0	0	0	38492
HOMING MISSILE GUIDANCE LAW	5	42	2.38	76.19	4 (3)	40 (2)	900	6320	20585	0	0	0	0	0	0	27849
MECHATRONICS	6	51	1.96	78.43	3 (3)	50 (3)	1130	50089	0	0	0	0	0	0	0	51272
COMBUSTION SOLID ROCKET PROPELLANTS	6	66	1.52	78.79	4 (4)	5 (1)	139 (1)	27205	0	0	0	0	0	0	0	27353
RELIABILITY ANALYSIS STRUCTURES	6	62	1.61	72.58	1 (1)	1 (1)	12 (3)	459 (1)	16051	40268	0	0	0	0	0	56792
NOZZLE NOISE REDUCTION	6	57	1.75	68.42	1 (1)	1	1 (1)	18 (3)	198 (1)	10713	0	0	0	0	0	10932
MANUFACTURING COMPOSITE STRUCTURES DESIGN	6	48	2.08	79.16	4 (4)	12 (1)	1331 (1)	32428	0	0	0	0	0	0	0	33775
ADAPTIVE CONTROL TRUSS STRUCTURES	6	51	1.96	78.43	6 (4)	69 (1)	961 (1)	41948	0	0	0	0	0	0	0	42984
PITTING CORROSION FATIGUE	6	52	1.92	76.92	2 (1)	20 (4)	201 (1)	5113	14604	0	0	0	0	0	0	19940
SOFTWARE SATELLITES	6	49	2.04	73.47	2 (2)	0	13 (3)	326 (1)	54291	0	0	0	0	0	0	54632
SPACEBORNE DOPPLER LIDAR	6	59	1.69	69.49	1 (1)	0	1	12 (5)	373	42782	0	0	0	0	0	43169

Search Terms	NOR	CODORS Recommendations													
		NDE	DEW	BF	95 - 100%	90- 95%	85- 90%	80- 85%	75- 80%	70- 75%	65- 70%	60- 65%	55- 60%	50- 55%	0- 50%	TR
UNGUIDED MISSILES	6	55	1.82	72.72	1 (1)	2 (1)	4 (2)	33 (2)	3467	22061	0	0	0	0	0	25568
COMPUTATIONAL FLUID DYNAMICS VISUALIZATION	7	58	1.72	82.76	10 (4)	125 (3)	9678	33381	0	0	0	0	0	0	0	43194
SURFACE TO AIR MISSILE	7	53	1.89	79.25	3 (3)	9 (2)	112 (2)	44867	0	0	0	0	0	0	0	44991
NOZZLE HYPERSONIC WIND TUNNEL	7	72	1.39	83.33	8 (6)	220 (1)	6805	20352	0	0	0	0	0	0	0	27385
BAYES RELIABILITY	7	54	1.85	81.48	3 (3)	58 (4)	7274	35654	0	0	0	0	0	0	0	42989
SIMULATION VHDL	7	60	1.67	80.00	2 (2)	6 (4)	348 (1)	48162	0	0	0	0	0	0	0	48518
AIRCRAFT AUTOPILOT	7	68	1.47	82.35	10 (5)	143 (2)	11063	29541	0	0	0	0	0	0	0	40757
CAD MEMS	7	55	1.82	78.18	1 (1)	11 (4)	407 (2)	46989	0	0	0	0	0	0	0	47408
MISSILE SYSTEM SIMULATION	8	72	1.39	84.72	12 (7)	357 (1)	45636	0	0	0	0	0	0	0	0	46005
SPACE PROPULSION ROCKET	8	82	1.22	80.49	3 (3)	27 (4)	566 (1)	29232	0	0	0	0	0	0	0	29828
GUIDANCE BALLISTIC MISSILE	8	68	1.47	80.88	2 (2)	7 (5)	866 (1)	36123	0	0	0	0	0	0	0	36998
MISSILE INTERCEPTION	8	68	1.47	83.82	6 (6)	49 (2)	38538	0	0	0	0	0	0	0	0	38593

Search Terms	NOR	CODORS Recommendations														
		NDE	DEW	BF	95 - 100%	90-95%	85-90%	80-85%	75-80%	70-75%	65-70%	60-65%	55-60%	50-55%	0-50%	TR
RAPID PROTOTYPING LASER	8	83	1.20	74.70	1 (1)	0	5 (4)	129 (3)	40503	0	0	0	0	0	0	40638
RAPID PROTOTYPING SIMULATION	8	71	1.41	84.51	8 (7)	633 (1)	56735	0	0	0	0	0	0	0	0	57376
DETECTION CORROSION AIRCRAFT STRUCTURES	8	83	1.20	83.13	16 (6)	98 (2)	10330	40709	0	0	0	0	0	0	0	51153
MEMS AEROSPACE	8	69	1.45	85.51	9 (7)	275 (1)	42046	0	0	0	0	0	0	0	0	42330
FLIGHT PROPELLANT PRODUCTION	9	69	1.45	84.06	7 (4)	133 (5)	16147	0	0	0	0	0	0	0	0	16287
ATTITUDE DETERMINATION GLOBAL POSITIONING SYSTEM	9	71	1.41	81.70	4 (4)	25 (2)	1764 (3)	48480	0	0	0	0	0	0	0	50273
COMPOSIT SOLID PROPELLANTS	9	89	1.12	85.39	9 (7)	114 (2)	28132	0	0	0	0	0	0	0	0	28255
MISSILE NONLINEAR AUTOPILOT	9	83	1.20	86.75	54 (9)	4296	26951	0	0	0	0	0	0	0	0	31301
ROCKET BOOSTERS	9	91	1.10	74.73	1 (1)	0	3 (3)	37 (5)	41965	0	0	0	0	0	0	42006
AGILE MANUFACTURING	9	70	1.43	85.71	11 (6)	293 (3)	27205	0	0	0	0	0	0	0	0	27509
SOFTWARE RELIABILITY ANALYSIS	9	79	1.27	82.28	2 (2)	23 (5)	2149 (2)	41611	0	0	0	0	0	0	0	43785
HIGH ANGLE OF ATTACK MISSILES	9	98	1.02	81.63	3 (2)	35 (4)	1780 (3)	38903	0	0	0	0	0	0	0	40721
HARDWARE-IN-LOOP SIMULATION MISSILE	9	73	1.37	84.93	10 (7)	245 (2)	31797	0	0	0	0	0	0	0	0	32052

Search Terms	NOR	CODORS Recommendations													
		NDE	DEW	BF	95 - 100%	90-95%	85-90%	80-85%	75-80%	70-75%	65-70%	60-65%	55-60%	50-55%	0-50%	TR
HYPERSONIC AIR BREATHING PROPULSION	10	105	0.95	81.90	2 (2)	12 (5)	997 (2)	41514 (1)	0	0	0	0	0	0	0	42525
SATELLITE TRACKING CONTROL	10	83	1.20	87.95	40 (10)	11758	38962	0	0	0	0	0	0	0	0	50760
GPS NAVIGATION SATELLITES	10	89	1.12	87.64	17 (9)	2951 (1)	47221	0	0	0	0	0	0	0	0	50189
MULTISENSOR MULTITARGET TRACKING	10	69	1.45	85.51	13 (6)	429 (4)	40699	0	0	0	0	0	0	0	0	41141
INCOMPRESSIBLE NAVIER-STOKES FLOW	10	92	1.09	84.78	11 (5)	1002 (5)	34844	0	0	0	0	0	0	0	0	35857
GRID COMPUTING	10	97	1.03	86.60	79 (8)	3240 (2)	41395	0	0	0	0	0	0	0	0	44714
SAFETY MANAGEMENT SYSTEM	10	68	1.47	85.29	13 (5)	370 (5)	30563	0	0	0	0	0	0	0	0	30946
HYPERSONIC WIND TUNNELS	10	102	0.98	84.31	4 (4)	150 (6)	48432	0	0	0	0	0	0	0	0	48586
MISSILE PROPULSION	11	119	0.84	87.39	8 (6)	973 (5)	42138	0	0	0	0	0	0	0	0	43119
COMPUTATIONAL FLUID DYNAMICS MODELING	11	125	0.80	85.60	4 (3)	407 (8)	63667	0	0	0	0	0	0	0	0	64078
RELIABILITY COMPOSITE STRUCTURES	11	109	0.92	84.40	1 (1)	135 (9)	65838 (1)	0	0	0	0	0	0	0	0	65974
STRUCTURAL ANALYSIS AIRCRAFT	11	103	0.97	88.35	91 (10)	16400 (1)	39046	0	0	0	0	0	0	0	0	55537
HIGH TC SUPERCONDUCTIVITY	11	105	0.95	80.00	1 (1)	3 (2)	156 (7)	32942 (1)	0	0	0	0	0	0	0	36102

Search Terms	NOR	CODORS Recommendations														
		NDE	DEW	BF	95 - 100%	90-95%	85-90%	80-85%	75-80%	70-75%	65-70%	60-65%	55-60%	50-55%	0-50%	TR
HYPERSONIC SHOCK TUNNEL	11	104	0.96	87.50	14 (10)	2867 (1)	40662	0	0	0	0	0	0	0	0	43543
NUMERICAL SIMULATION COMPUTATIONAL FLUID DYNAMICS	12	124	0.81	88.71	93 (12)	10934	15032	0	0	0	0	0	0	0	0	26059
MICRO AIR VEHICLES	12	106	0.94	86.68	36 (11)	12716 (1)	41271	0	0	0	0	0	0	0	0	54023
HYPERSONIC FLIGHT CONTROL	12	103	0.97	88.35	52 (11)	13434 (1)	32309	0	0	0	0	0	0	0	0	45795
AIRCRAFT MANUFACTURING	12	112	0.89	89.29	108 (11)	55700 (1)	0	0	0	0	0	0	0	0	0	55808
GUIDED MUNITIONS	13	114	0.88	90.35	53 (12)	65365 (1)	0	0	0	0	0	0	0	0	0	65418
AEROSPACE PROPULSION	13	114	0.88	89.47	22 (12)	55449 (1)	0	0	0	0	0	0	0	0	0	55471
AIRCRAFT FLIGHT DYNAMICS	13	117	0.85	88.89	74 (12)	15830 (1)	37966	0	0	0	0	0	0	0	0	53870
SIMULATION FLIGHT DYNAMICS	13	124	0.81	84.68	1 (1)	103 (11)	72079 (1)	0	0	0	0	0	0	0	0	72183
MISSILE AUTOPILOT DESIGN CONTROL	13	115	0.87	87.83	17 (8)	6418 (5)	41483	0	0	0	0	0	0	0	0	47918
ADAPTIVE VIBRATION CONTROL STRUCTURES	13	114	0.88	85.96	4 (3)	1653 (10)	60431	0	0	0	0	0	0	0	0	62088
CORROSION RESISTANT COATINGS	13	150	0.67	88.67	11 (9)	4607 (4)	44764	0	0	0	0	0	0	0	0	49382
FLIGHT CONTROL SOFTWARE	14	107	0.93	89.72	154 (12)	60451 (2)	0	0	0	0	0	0	0	0	0	60605

Search Terms	NOR	CODORS Recommendations														
		NDE	DEW	BF	95 - 100%	90- 95%	85- 90%	80- 85%	75- 80%	70- 75%	65- 70%	60- 65%	55- 60%	50- 55%	0- 50%	TR
PROBABILISTIC STRUCTURAL ANALYSIS	14	139	0.72	89.21	29 (11)	20907 (3)	39686	0	0	0	0	0	0	0	0	60622
FATIGUE LIFE ASSESSMENT	14	137	0.73	90.51	324 (13)	57357 (1)	0	0	0	0	0	0	0	0	0	57681
FATIGUE AIRFRAME	14	144	0.69	87.50	22 (4)	4256 (10)	55803	0	0	0	0	0	0	0	0	60081
FLIGHT SIMULATION SOFTWARE	14	107	0.93	87.85	10 (6)	4702 (8)	57158	0	0	0	0	0	0	0	0	61870
LYAPUNOV EQUATIONS	14	103	0.97	88.35	40 (8)	13700 (6)	31946	0	0	0	0	0	0	0	0	45686
AIRCRAFT DRAG	15	157	0.64	89.81	23 (11)	59747 (4)	0	0	0	0	0	0	0	0	0	59770
ROBOT SOFTWARE	15	119	0.84	89.92	197 (11)	69884 (4)	0	0	0	0	0	0	0	0	0	70081
MISSILE AERODYNAMICS	16	164	0.61	87.80	13 (5)	3239 (11)	55762	0	0	0	0	0	0	0	0	59014
SOLID PROPELLANT ROCKET MOTORS	16	117	0.57	90.96	55 (15)	71592 (1)	0	0	0	0	0	0	0	0	0	71647
AIRCRAFT FLIGHT CONTROL SYSTEMS	16	159	0.63	88.05	3 (3)	3848 (13)	71140	0	0	0	0	0	0	0	0	74991
SAFETY SPACE SYSTEMS	16	142	0.70	87.32	3 (3)	700 (13)	45193	0	0	0	0	0	0	0	0	45896
UNSTEADY ROTOR AERODYNAMICS	17	147	0.68	89.80	132 (11)	58736 (6)	0	0	0	0	0	0	0	0	0	58868
VIRTUAL MANUFACTURING	18	171	0.58	91.81	201 (18)	71778	0	0	0	0	0	0	0	0	0	71979

Designing Content-based Document Recommender System for Aerospace Grey Literature

(Questionnaire for Users/Readers)

Investigator: **K. Nageswara Rao**
Supervisor: **Prof. V.G. Talwar**

1. Name & Designation : ………………………………………………………………………….

2. Belongs to : ……………………………………………………………………………..….……

3. How familiar are you with Online Public Access Catalogs of libraries?
☐ Not very familiar ☐ Familiar ☐ Very familiar

4. What is your experience about matching of key terms when you entered into OPAC while searching for documents of your interest?
☐ Got 100% matching ☐ Matching between 75-99%
☐ Matching between 50-74% ☐ Matching between 25-49%
☐ Matched below 24%

5. When you got hits were the references ranked in the order of relevance?
☐ Yes ☐ No

6. In OPAC, did you get hits for the key terms that did not match?
☐ Yes ☐ No

7. Other than OPACs, have you heard of 'Filtering Systems' for identifying relevant information?
☐ Yes ☐ No

8. Have you heard of 'Recommender Systems' for identifying relevant information?
☐ Yes ☐ No

9. Are you aware of Thesaurus and its importance in information retrieval?
☐ Yes ☐ No

10. Are you aware of concept-based searching?
☐ Yes ☐ No

11. Are you aware of CODORS?
☐ Yes ☐ No

12. Have you ever used CODORS to search information of your requirement?
☐ Yes ☐ No

13. If you have used CODORS, how frequently you have searched using CODORS?
☐ Daily ☐ Thrice in a week ☐ Twice in a week
☐ Once in a week ☐ Once in 2 weeks ☐ Ralely

14. While using CODORS, did your search find anything useful and interesting?
☐ Yes ☐ No

15. What was the result of hits from your CODORS search?
- [ ] It was what I expected
- [ ] More than what I expected
- [ ] Less than what I expected

16. When you used CODORS, how relevant were the hits?
- [ ] Not relevant
- [ ] < 25% relevant
- [ ] Between 26-50% relevant
- [ ] Between 51-75 % relevant
- [ ] Between 76-99% relevant
- [ ] 100% relevant

17. How easy is it to search CODORS?
- [ ] Not easy
- [ ] Easy to some extent
- [ ] Moderately easy
- [ ] Very easy

18. Did you fee frustrated while using CODORS?
- [ ] Yes
- [ ] No

19. Are you convinced with the display of percentage relevance ranking of results in CODORS?
- [ ] Yes
- [ ] No

20. Is CODORS useful for finding relevant articles on a particular subject?
- [ ] Yes
- [ ] No

21. Are CODORS results comprehensive on a particular subject your interest?
- [ ] Yes
- [ ] No

22. In CODORS, did you get hits for the key terms that did not match titles?
- [ ] Yes
- [ ] No

23. If yes, what was the percentage of such success?
- [ ] <25%
- [ ] Between 25-49%
- [ ] Between 50-74%
- [ ] Between 75-99%
- [ ] 100%

24. Did you search for documents of your interest keeping in mind its highest relevance?
- [ ] Yes
- [ ] No

25. In such cases, did you get more references in ranked order in addition to the one you were looking for?
- [ ] Yes
- [ ] No

26. If yes, were the other documents ranked above the one you considered more relevant?
- [ ] Yes
- [ ] No

27. If yes, how did you find such documents, which were tanked above the document you considered relevant?
- [ ] Most relevant
- [ ] More relevant
- [ ] Not much difference
- [ ] Not relevant