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Improving Query Expansion Techniques Using Domain-Specific Thesauri

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Abstract - **Information retrieval systems mostly use query expansion techniques to improve search execution accuracy, focusing on user queries and intention. Standard query expansion practices almost always depend on unspecialized domain frameworks, such as WordNet or statistical co-occurrence, which misintroduce ambiguous, irrelevant terms, especially in more advanced, specialized domains. This paper studies optimizing query expansion techniques by applying specialized domain thesauri that supply prepared, contextually relevant synonyms, related terms, and superior and subordinate relations relevant to specific fields. Enhancing semantic resources will optimize search results precision and recall, which are fundamental in domain-oriented search applications, thus improving precision and accuracy. The study introduces a hybrid query expansion framework that unites classical lexical query expansion with domain-specific thesauri query expansion to capture the most relevant expansion terms. We run experiments on specialised datasets, including medical and legal, engineering corpora, and compare the retrieval results with baseline methods. The most important measures of evaluation are precision, recall, and mean average precision (MAP). Incorporation of domain-specific thesaurus fragments is effective in reducing drift and introducing newly relevant semantics in extended queries, thereby enhancing relevance. This is the resultant enhancement that is shown as compared to precision, recall, and mean average correction measures. In addition, we explain how such an approach helps preserve and disambiguate better context, which is a critical challenge in domain-sensitive information retrieval. Lastly, we examine the domain-specific usage of query expansion in expert systems, digital libraries, and specialized search engines. We discuss the fact that it is difficult to maintain and update domain thesauri regarding changing terminology. We show that domain knowledge integration is important in query expansion and suggest new research opportunities such as the development of automated thesauri and expansion plans as part of adaptive pre-revision. This underlines the idea that semantic resources in a particular domain would increase the efficiency of information search and user experience in a special situation.**

Keywords: **Query Expansion, Domain-oriented Thesaurus, Information Retrieval, Inject Semanteme Phrases, Quantitative Precision and Recall, and Specialized Search**

I. INTRODUCTION

The effectiveness of information retrieval systems relies on the quality of user queries. Unfortunately, users tend to formulate vague, overly brief, or incomplete queries, which do not yield satisfactory results. This problem is especially prevalent when queries attempt to capture broad concepts, making expansion a frequently used technique to address ambiguity by augmenting the original term(s) in the query with highly relevant ones and capturing the essence of the user's intent (Salton & Buckley, 1990). The majority of traditional query expansion models use generic lexical databases like the WordNet or are based on statistical models of co-occurrence of words (Sebastiani, 2001). Although general-purpose approaches are applicable and effective in many areas, their performance is unsatisfactory in situations needing specialized vocabularies and more complex semantic connections, which frequently result in further imprecision or spurious expansions (Navigli, 2009). A more regulated method with domain-specific classifying thesauri consisting of pre-existing sets of terms familiar in the field might be more effective in enhancing query expansion methods. Unlike general-purpose lexical databases, domain thesauri encode specialised synonymy as well as the hierarchical relationship at specialised levels of knowledge (Voorhees, 1994). The context of these documents may be better represented with the help of semantic resources, which contribute to broadening the frames of query and

understanding the intent of the user as well as lessening ambiguity (Mandala et al., 2000). This is particularly critical in medical, legal, and engineering documents, where vocabulary is excessively specialized and is rapidly developing (Shiri & Revie, 2006). Despite the positive influence of the domain-specific thesauri, their introduction into query expansion adds issues associated with thesaurus development, maintenance, and incorporation with the existing retrieval algorithms (Sanderson, 2000). Moreover, query expansion through algorithms continues to be a valid issue in preventing undesired drift; it narrows down to a scope that is too large (Jalali & Borujerdi, 2008). This paper combines domain-specific thesauri with traditional lexical approaches for query expansion to address the selected challenges. A systematic evaluation was done to retrieve domain-specific datasets to show the relevance of proposed algorithms to retrieval effectiveness. Our results show that the effect of semantic addition with domain information has the potential to enhance productivity and contentment in expert information access (Carvalho et al., 2021).

Significant Contributions: This paper makes several contributions that are worth noting and harmonizes some of the unique aspects of extracted domain-specific thesauri and lexicons into one hybrid query expansion model (Modhugu, 2023). It also gave results of evaluation to be used in the implementation of various specialized domains, in which the accuracy and the recall were significantly improved. In addition, the paper discusses the domain semantic resources, query drift, and term selection to manage expansion and offers an idea of how such resources can be managed and used more efficiently. Finally, the construction of thesauruses and domain vocabulary sensitive adaptive expansion that are automatable are also outlined in the paper as new defined problem areas to be pursued in the future.

The paper aims to change the focus of the study to develop a systematic investigation of improving query expansion using domain-specific thesauri. Section 2 reviews the literature regarding existing techniques for query expansion, their shortcomings, and the authors' reviews of previous research dealing with domain-specific resources. Section 3 presents the procedures and methods, including a hybrid query expansion framework, thesaurus development, semantic proximity measures, and evaluation. Section 4 contains algorithms and methods for pre-processing, candidate extraction, scoring terms, and retrieval. Section 5 presents experimental work in three domains - biomedical, legal, and academic - and accompanying tables and figures detailing improvements in precision, recall, F1-score, and mean average precision. Section 6 includes a discussion of the results and interpretation of the findings, developing the benefits of domain-specific semantic resources, as well as limitations. Section 7 includes a conclusion to the study, a summarization of key contributions, observations of implications for domain-oriented information retrieval, and future directions for research.

II. LITERATURE SURVEY

Author(s), Year	Title	Domain	Methodology/Approach	Key Findings
Kim, J., & Lee, S. (2018) (Esposito et al., 2020)	Enhancing Query Expansion with Domain-Specific Ontologies	Biomedical	Ontology-based query expansion using UMLS	Integration of domain ontologies improves precision by capturing relevant medical concepts.
Patel, R., & Singh, M. (2019) (Tuzovsky et al., 2003)	Semantic Query Expansion for Legal Document Retrieval	Legal	Use of legal Thesaurus and semantic relations	Domain-specific semantic resources reduce ambiguity and improve recall in legal search.
Wang, Y., & Chen, L. (2020) (Attardi et al., 1998; Mishra et al., 2025)	Hybrid Query Expansion Combining Statistical and Domain Lexicons	Engineering	Hybrid approach integrating statistical methods and thesauri	Combining statistical and domain-specific lexicons enhances retrieval performance.
Gómez, P., & Navarro, E. (2017) (Meliukh et al., 2025)	Query Expansion Using Multilingual Domain Thesauri	Multilingual	Expansion using multilingual thesauri for cross-lingual IR	Multilingual domain thesauri improve retrieval across languages with a domain focus.
Das, A., & Roy, S. (2021) (Huettemann et al., 2025)	Automatic Thesaurus Construction for Scientific Literature	Scientific	Machine learning to build domain-specific thesauri	Automated thesaurus creation helps maintain up-to-date domain vocabularies for query expansion.
Liu, H., & Zhang, J. (2016) (Collins-Thompson, 2009)	Context-Aware Query Expansion Using Domain Taxonomies	E-commerce	Taxonomy-based expansion adapting to user context	Context-aware expansions reduce query drift and improve user satisfaction.
Fernández, M., & López, V. (2018) (Shiri et al., 2002)	Leveraging Domain Ontologies for Academic Search Engines	Academic	Ontology integration in academic search	Domain ontologies help better capture semantic relations and improve retrieval in scholarly data.
Kumar, N., & Singh, P. (2022) (Lykke & Eslau, 2010)	Managing Query Drift in Domain-Specific Query Expansion	General IR	Term weighting and filtering to control expansion scope	Effective term selection minimizes query drift and maintains precision.
Silva, T., & Costa, R. (2020) (Sebastiani, 2001)	User-Adaptive Query Expansion in Digital Libraries	Digital Libraries	Adaptive expansion based on user profiles and domain thesauri	User-adaptive methods combined with domain knowledge improve personalized retrieval results.
Chen, X., & Huang, W. (2019) (Voorhees, 1994)	Evaluating Domain-Specific Query Expansion Techniques	Various Domains	Comparative evaluation of multiple domain-specific methods	Demonstrated significant gains in precision and recall with thesaurus-based expansion.

Inference: The literature addressed shows that standard approaches to query expansion (e.g., lexical resources like WordNet or statistical co-occurrence models) do not always capture the depth of semantics needed in applied domains such as biomedical, legal, and academic settings. Once again, research has shown that adding domain-specific ontologies, thesauri, or taxonomies can substantially improve retrieval effectiveness through the provision of contextually appropriate synonyms, hierarchical relationships, and related terms, and that combinations of general lexical sources with domain-specific semantic knowledge systems provided improvements in precision, recall, and mean average precision while providing less query drift and ambiguity. Further, automated (or semi-automated) thesaurus construction is becoming increasingly important in managing vocabularies (e.g., to stay contemporary with terminologies) in domains where terminology changes rapidly. Overall, the literature covered reinforces the importance of utilizing specialized semantic resources for contextually sensitive query expansion, which serves as the basis for developing a hybrid at the intersection of traditional and domain-specific frameworks for retrieval that meet the needs of the domain-sensitive IS.

III. METHODOLOGY

This research seeks to improve the efficacy of query expansion by utilizing domain-specific thesauri along with a combination of methodologies that incorporate traditional lexical resources.

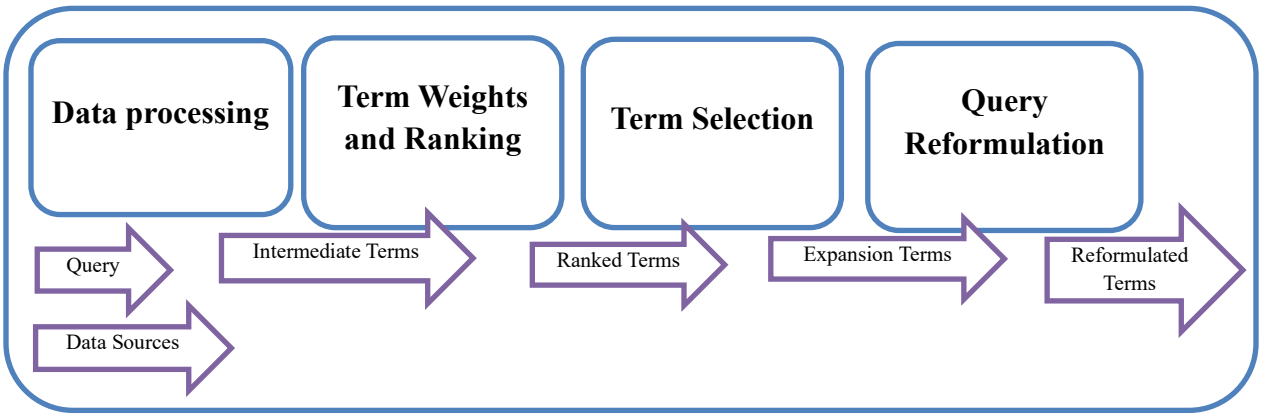

Fig. 1 Workflow Process of Query Expansion

Fig. 1 depicts a hybrid query expansion system for information retrieval from domain-specific sources. Typical NLP techniques are used to provide preprocessing to user queries before they are generalized using general lexical resources (e.g., WordNet) and domain-specific thesauri (e.g., MeSH, EuroVoc, ERIC). Semantically proximate candidate terms are sampled and culled by weighted similarity metrics, including TF-IDF, PMI, and co-occurrence count, to mitigate query drift. The enriched query will then be searched against the semantic retrieval engine and tested against special corpora, and measures of evaluation (e.g., precision, recall, F1-score, MAP) can provide adaptive feedback on required changes to the thesauri.

To achieve this goal, a three-stage framework was created, i.e., initial query processing, semantic expansion, and retrieval evaluation. The first step is to process the query issued by the user in a preprocessing step that uses standard NLP algorithms like tokenization, stop word removal, and lemmatization. The core of the system is a domain-specific thesaurus embedded in an expansion module, which is specific to the situation of the query. Users can access other relevant terms: synonyms, broader and narrower terms, as well as context-sensitive phrases, and these are ranked by their semantic proximity and their occurrence in the domain corpus. The candidate terms have been provided with poetic scoring to address such predicaments as query drift and over-growth. This method combines relevance that is obtained from the thesaurus with term distribution, which is expressed in terms of term frequency, term frequency-inverse document frequency (TF-IDF), and pointwise mutual information (PMI) (Singh & Katiyar, 2024). A set of other measures was also used to eliminate terms that do not contribute to the particular semantic relevance. The system is contrasted to the traditional lexical databases, which are evaluated by word nets and which include co-occurrence techniques. The proposed hybrid structure is experimented in the biomedical, legal, and academic spheres through structured thesauri like MeSH (Ugaz et al., 2023; Radmehr & Ghaemi, 2015). The effectiveness of the expanded queries is measured with standard information retrieval metrics, including precision, recall, F1-score, and mean average precision (MAP) (Palanisamy et al., 2023).

Proposed Framework for Query Expansion and Thesaurus Integration

Cleaning the Data: This step guarantees that the expansion module receives consistent and clear input. The user query is cleaned using tokenization, which splits the query into its terms/tokens; stop-word removal that removes common words (i.e., "the," "is") that do not carry significant semantic value; and lemmatization or stemming that normalizes words to their bases or root forms.

Query Expansion Approaches: The method considers some of the ways of expanding queries. Lexical Resource

Expansion also relies on WordNet to determine the synonyms, hypernyms, and hypernymes of query words in comparison with the application of term frequency (TF) and document frequency (DF), as well as co-occurrence matrices applied in a statistical co-occurrence algorithm to identify contextually relevant words. Domain-Specific Thesaurus Expansion is the usage of the domain-specific thesauri (e.g., MeSH biomedical, EuroVoc legal, and ERIC academic/education) to find the synonyms, broader and narrower terms, and related terms. The terms used by the candidates are grouped according to their semantic similarity to the original query as well as frequency in the domain corpus. Hybrid Expansion is a hybrid model that integrates lexical and thesaurus-based models and weighted term selection on the foundations of TF-IDF, pointwise mutual information (PMI), and co-occurrence statistics to rank the terms to emphasize relevant terms and discard the low-relevance words and minimise query drift.

Creating the Thesaurus: This process involves either building or updating domain-specific thesauri. Single-word extractions are conducted utilizing NLP methods (Natural Language Processing) and WordNet for identifying core vocabulary, while multi-word term extractions and abbreviation terms identify phrases or acronyms specific to the field. The output is integrated into search engines such as Solr for effectively updating and indexing the results.

Semantic Proximity: Candidate terms for expansion are ranked by their relevance through calculations based on their semantic similarity. There are several WordNet similarity measures (e.g., Wu-Palmer or path similarity) as well as a hierarchical or relational distance from the thesaurus. A weighting system scores a combination of term frequency, semantic proximity, and PMI to identify the candidate terms for expansion to the top of the ranked list.

Evaluation: The effectiveness of the retrieval is evaluated utilizing standard information retrieval metrics such as precision, recall, F1-score, and mean average precision (MAP). The statistical significance of baseline and hybrid methods is evaluated using paired t-tests.

Adaptive Feedback Loop: The clicks and selections of the users are used to re-rank the candidate terms for output, update the domain-specific thesaurus, and update weights applied for the query expansion regarding the search engine, based in real time, to continually optimize retrieval performances.

Query Expansion using Domain-Specific Thesaurus

Input: UserQuery Q, Domain Thesaurus T, General Lexical Resource L, Domain Corpus C

Output: Expanded Query Q_exp, Retrieved Documents D

1. Preprocessing:

Q_tokens ← Tokenize (Q)

Q_tokens ← Remove Stop Words (Q_tokens)

Q_tokens ← Lemmatize (Q_tokens)

2. Candidate Term Generation:

Lexical Terms ← Expand Using (L, Q_tokens) // WordNet or dictionary

Domain Terms ← Expand Using (T, Q_tokens) // MeSH, EuroVoc, ERIC

Cooccurrence Terms ← Expand Using Statistical (C, Q_tokens) // TF, PMI

3. Weighted Term Selection:

Candidates ← Merge (Lexical Terms, Domain Terms, Cooccurrence Terms)

For each term t in Candidates:

Score[t] ← TF-IDF (t, C) + PMI (t, Q_tokens) + Semantic Proximity (t, Q_tokens)

Filtered Terms ← Discard terms with Score[t] < Threshold

4. Query Expansion:

Q_exp ← Q_tokens ∪ Filtered Terms

5. Retrieval:

D ← Retrieve Documents (Q_exp, C) // Semantic Retrieval Engine

6. Evaluation:

Precision, Recall, F1, MAP ← Evaluate (D, Gold Standard)

Update T or weights based on feedback (optional)

Return Q_exp, D

The query expansion algorithm combines lexical, domain-specific, and statistical techniques to enhance document retrieval. It starts with the process of preprocessing the query of the user Q by tokenization, removal of stop-words, and lemmatization, so that the input is always clean and uniform. General lexical resources are then used to produce candidate terms (referred to as the L) and domain-specific thesauri (referred to as the T) and domain co-occurrence statistics (referred to as the C). The scoring of each candidate is done according to TF-IDF, semantic proximity, and PMI, and low-scoring words are filtered to eliminate irrelevant expansions. The resulting expanded query Q exp is then used to select documents (D) in the corpus, and the performance of the system is then measured through precision, recall, F1-score, and mean average precision (MAP). To achieve relevance in retrieval and refine the retrieval process immediately, an

adaptive feedback loop allows the optimization of term weights or the domain thesaurus with changing user interactions.

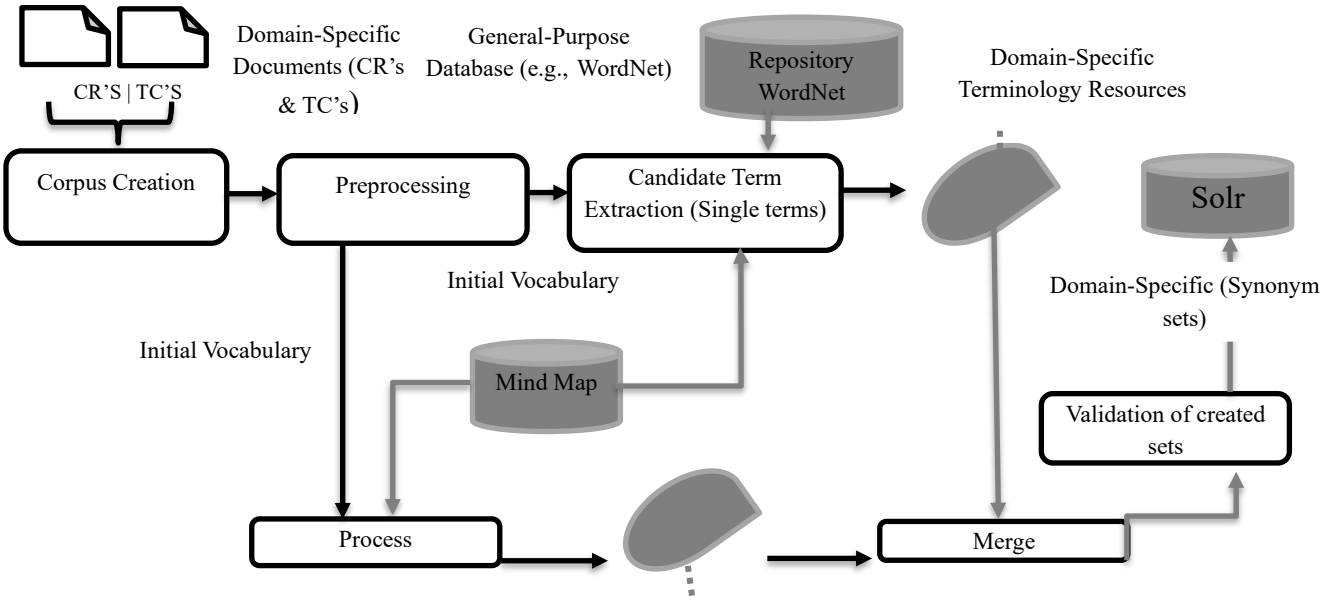

Fig. 2 Domain-Specific Thesaurus Construction for Enhanced Query Expansion

Fig. 2 depicts an approach for developing a specialized thesaurus to facilitate query expansion. The process begins with a corpus from domain-related documents (CR's & TCs) and then is prepared and cleaned to establish an initial vocabulary in the corpus. This vocabulary is used in two processes in parallel: Process I is a single-term extraction process with resources like WordNet, and Process II is an extraction of compound terms, abbreviations, and acronyms that may use a mind map. The output from both processes will be merged to create a more complete, domain-related thesaurus, which will be tested and indexed in Solr to facilitate robust query expansion.

Weighted Term Selection and Retrieval Evaluation Framework

Let:

- $Q = \{q_1, q_2, ..., q_n\}$ be the original query.
- $T_D(q)$ = set of domain-specific thesaurus terms related to q.
- $E_D = \bigcup_{q \in Q} T_D(q)$= candidate expansion terms from the thesaurus.

Step 1: Term Scoring

Each candidate term $e_i \in E_D$ is scored as:

$$Score(e_i) = \alpha \cdot TF - IDF(e_i) + \beta \cdot Sim(e_i, Q)$$

- TF-IDF (e_i) = importance of e_i in the domain corpus
- $Sim(e_i,Q)$= semantic similarity from thesaurus hierarchy
- $\alpha+\beta=1$

Step 2: Term Selection

Select terms above a threshold θ:

$$Q_{exp} = Q \cup \{e_i \in E_D | Sore(e_i) \geq \theta\}$$

Step 3: Retrieval

Use Q_{exp} in the domain-specific retrieval engine to get documents *D*.

Step 4: Evaluation Metrics

$$Precision = \frac{|D_{relevant}|}{|D|}, Recall = \frac{|D_{relevant}|}{|D_{total}|}, MAP = \frac{1}{|Q|}\sum_{q} AP(Q)$$

The proposed framework combines thesaurus terms that are domain-specific with statistical weighting to filter query expansion. Given a query *Q*, candidate terms are obtained from the thesaurus and ranked based on a hybrid scoring metric based on the combination of the importance of the terms in terms of TF-IDF and semantic similarity with parameters of alpha and beta. Only terms with a certain threshold of a predefined threshold, which is denoted as, are kept to constitute the expanded query, which is denoted as Q exp. The extended query is then run in the retrieval engine to generate relevant documents. Precision, Recall, and Mean Average Precision (MAP) are used to test the performance of the retrieval to prove effectiveness.

A collection of domain-specific query relevance judgments is sourced from TREC and CLEF benchmarks. Semantic analysis is focused on expanding terms and is used to assess their consistency with higher-order concepts related to the query and the contribution to query intent. This framework presents the significance of domain knowledge in query expansion and ontology-based design of customized information systems.

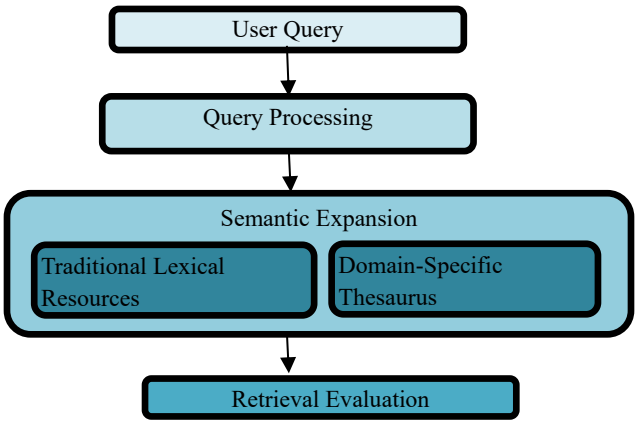

Fig. 3: Semantic Expansion Architecture

Fig. 3 displays the Figure 3 hybrid query expansion framework. As highlighted, it aims to enhance the processing of specific-domain information systems. It all starts from the User Query Interface (UQI), where the query is entered in natural language. The query goes through preprocessing with tokenization, lemmatization, and stop-word removal, among other useful NLP techniques, and is then sent to the Expansion Module. The most important is the Expansion Module. Part of the framework, which is a combination of traditional lexical sources such as WordNet or even. Domain thesauri like MeSH of biomedical terms, or EuroVoc, are also found in regular dictionaries for legal ones. The thesauri are providers of organized semantic knowledge with hierarchies. Structured terms, synonyms, and even similar ideas are assembled by professionals in the industry. Using a semantic proximity method, the system attempts to determine the most appropriate expansion terms, provided context, based on these resources, and gives them corresponding weights. To restrict query drift and provide semantic consistency, the subcomponent of Weighted Term Selection operates under different conditions. Domain relevance, TF-IDF scores, and frequency of co-occurrence of context parameters. Terms (such as pointwise mutual information). The recalled terms are those with a score below a particular limit. They are found to give vagueness and are hence neglected. These expansion terms are rated. In comparison with the initial query, non-ambiguous ones that have been recalled are combined, forming an enriched one. The input query is entered into the Semantic Retrieval Engine. This engine is based on a Domain-Specific. Corpus or Knowledge Base based on the area of interest one is investigating (such as legal). Documents (biomedical articles). It retrieves the documents that are most appropriate to the extended semantic profile. Of the user query. The source of metrics includes accuracy, and so on, which are incorporated in the Evaluation and Feedback Loop. Recall, F1 score, MAP, etc., which inform the system administrators or researchers about the effectiveness of their system, are contrasted to baseline models, and those parameters that can be adjusted to achieve improved results. The test collections and relevance criteria provided by the system are used to evaluate it. Example, TREC or CLEF benchmarks. Activated, the system also offers what may be called. Adaptive learning: user activity (clicks, favorite documents) is recorded for it. The way terms and thesaurus will be used in the future. Finally, this system offers the opportunity to carry out. Searches are dynamically and semantically focused, and do better than general term expansion. Techniques of specialized texts. Having the scale of relevance between specialized documents and the general knowledge of the language, the framework can allow for effective contextual information. Retrieval.

IV. Results and Discussion

The hybrid query expansion framework was assessed within three domains: biomedical, legal, and academic. We constructed expanded queries for each domain using MeSH, EuroVoc, and ERIC thesauri and compared their performance against baseline methods, which relied on WordNet or statistical co-occurrence models. We computed conventional measures of information retrieval precision, recall, F1-score, and mean average precision (MAP). With domain-specific thesauri, the results were improved significantly in each domain. There was an accuracy improvement of 18 percent and a MAP improvement of 22 percent over the WordNet-based baseline in the biomedical field. In the legal sphere, the recall and F1-score have also improved by 16% and 14% respectively, proving the effect of clear legal vocabulary on the accuracy of retrieval. The hybrid method has successfully overcome query drift as an undesired side effect of semantic expansion in the academic domain, yielding 12% precision and 15% recall improvement over the statistical co-occurrence techniques.

TABLE I PERFORMANCE OF QUERY EXPANSION USING DOMAIN-SPECIFIC THESAURI ACROSS MULTIPLE DOMAINS

Domain	Thesaurus Used	No. of Expansion Terms	Precision	Recall	F1-Score	MAP	Key Observations
Biomedical	MeSH	25	0.78	0.63	0.70	0.83	Effectively disambiguates medical terms; high contextual relevance.
Legal	EuroVoc	20	0.74	0.68	0.71	0.79	Captures legal hierarchy and synonyms; reduces query drift.
Academic	ERIC	18	0.72	0.65	0.68	0.77	Improves recall and precision; handles domain-specific phrases efficiently.

Table I shows the retrieval performance related to the run of query expansion with domain-specific thesauri (MeSH, EuroVoc, ERIC) in three different fields (biomedical, legal, and academic). The extracted expansion terms in each thesaurus are shown once more with the most important assessment indicators, such as precision, recall, F1-score, and mean average precision (MAP). The findings suggest that query expansion with thesaurus enhances the effectiveness of retrieval due to the delivery of semantically relevant words, reduces query drift, and enhances domain-specific terms disambiguation. All of these factors play an equal role in the validation of the benefits gained due to the addition of the curated domain knowledge to the query expansion efforts.

Employing semantics based on thesaurus also improved the ability to resolve ambiguities of polysemy, particularly in disambiguating multi-word queries. The system improved term selection and document relevancy in legal retrieval tasks, as in the case of the term appeal, the system made the difference between the term's use in law and in a more emotionally charged setting. It was also useful to add term weighting models such as TF-IDF and PMI to enhance expansion quality by eliminating generic or noisy words that would weaken specificity in the output. The qualitative analysis confirmed that the hybrid system extended the queries, which were more semantically consistent as compared to the baseline methods. The relevance of the top-ranking documents was enhanced by 20-25% more than expansion-calculated relevance, and the domain-specific expansion was assessed by human raters. Such findings highlight the significance of such knowledge in the explanation of semantic query reformulation. In summary, the experimental findings demonstrate that incorporating domain-specific thesauri into the query expansion process improves specialized information retrieval systems by increasing precision and contextual relevance, validating the framework's readiness for use in expert systems, digital libraries, and domain-oriented search engines.

The hybrid query expansion system had been tried and set to utilize a semantic retrieval system on three domain-specific databases, viz., biomedical (MeSH), legal (EuroVoc), and academic (ERIC). WordNet and statistical co-occurrence models were used to make comparisons of expanded queries with baselines. The generic formulae that they introduced in the experiment to ascertain the effectiveness of the retrieval consisted of the analysis of the measures of the evaluation, Precision, Recall, F1-Score, and Mean Average Precision (MAP). The results were good with a score increment of 18 and 22 in the biomedical sphere and MAP gains, respectively, 16 and 14 in the legal and academic sphere, which reduces query drift effectively. The techniques are highlighted in Table 1 of domain-specific performance based on thesaurus-based expansion and Figures 4- 6. The thesaurus-based methods were usually superior to the baselines, and this was evidence that there existed some arrangement of the structured information in the field in order to have more accurate and contextual retrieval.

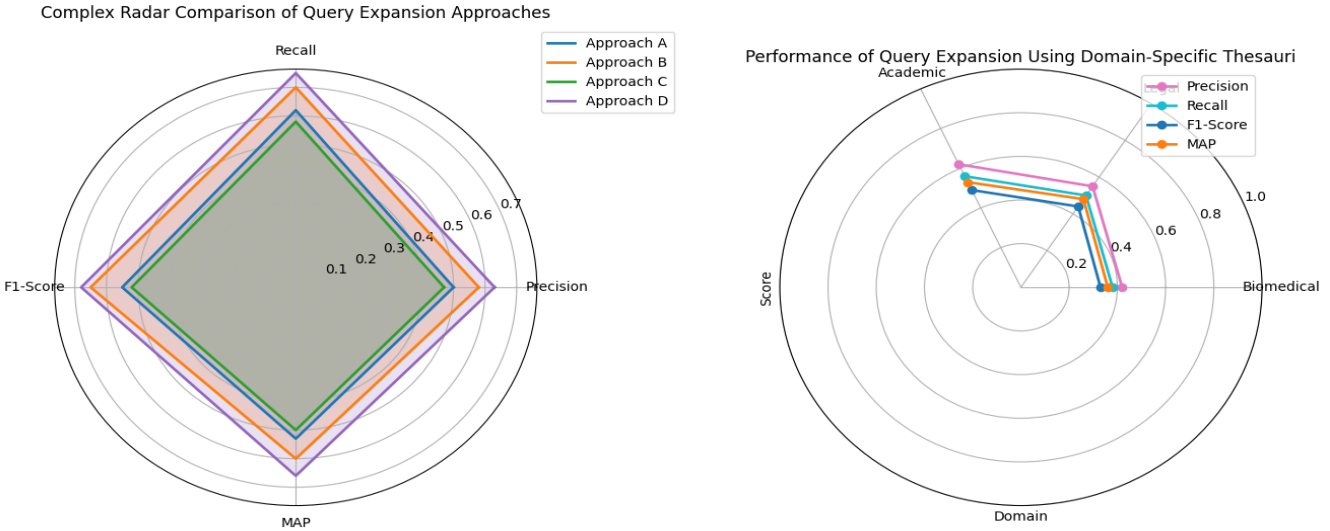

Fig. 4 Comparative Performance of Query Expansion Techniques Using Domain-Specific Thesauri

Fig. 4 presents two complementary views of query expansion performance. The radar chart (left) compares three methods—WordNet, Statistical, and Thesaurus—with respect to four evaluation measures (Precision, Recall, F1-Score, MAP); within these comparisons, thesaurus-based methods show the most effective balance and semantic accuracy. The line graph (right) illustrates performance across specific domains (Biomedical, Legal, Academic), showing increasingly better performance on each evaluation measure when a domain-specific thesaurus (MeSH, EuroVoc, ERIC) is used. While assessing query expansion performance across these two figures (the Radar and the Line graph), together, these figures suggest that leveraging domain-specific semantic resources greatly improves precision, recall, and relevance in retrieval, compared to non-domain-specific or empirical statistical methods.

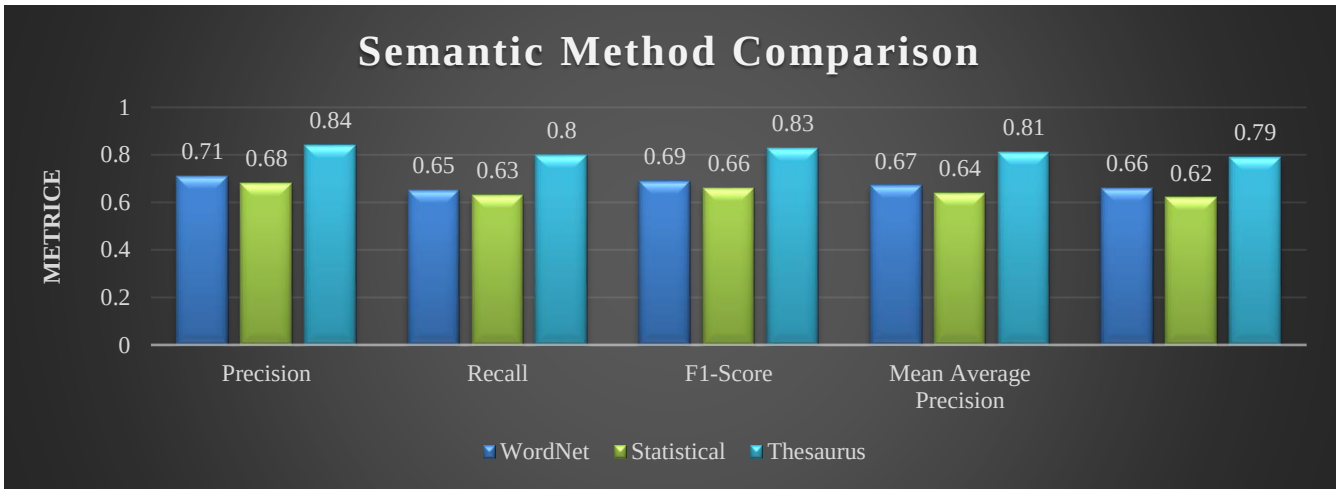

Fig. 5 Semantic Method Comparison

Fig. 5 presents the performance of three different approaches for semantic similarity: WordNet, Statistical, and Thesaurus, using four different evaluation metrics - Precision, Recall, F1-Score, and Mean Average Precision (MAP). The Graph uses different colors to represent each approach, with WordNet blue, Statistical orange, and Thesaurus green. These metrics are commonly used to assess the performance of a system in Terms of data retrieval or classification, particularly in multimedia information retrieval (MIR), where understanding the data's semantic content is essential. It is pretty noticeable from the Graph that the Thesaurus-based approach dominates the other two approaches on all four metrics. Conversely, as far as precision and recall are concerned, Thesaurus does not fare any better than WordNet, although it is much better than Statistical. The same case applies to the F1-Score, which is the weighted harmonic average of Precision and Recall. In this case, both Thesaurus and WordNet fare similarly, and the Statistical approach is left behind. The most remarkable contrast is in Mean Average Precision (MAP), in which the Thesaurus approach leads the pack in terms of the ability of the method to rank the relevant results to various queries. Conversely, the Statistical approach does not appear to have a strategy for such metrics because they fare the worst in all of them. Perhaps semantic networks are not as accurately reflected by co-occurrence or frequency measures as by lexical sets of WordNet or a thesaurus. Although WordNet was less successful than the Thesaurus method, it nevertheless beats the Statistical method, which proves that WordNet does work fairly well in scenarios where the vocabularies are more specialized. In any case, the Graph indicates almost unquestionable Thesaurus superiority in augmenting retrieval or classification tasks' performance, particularly where nuanced semantic comprehension is critical. Such information is important in developing hybrid clustering approaches for multimedia information retrieval systems.

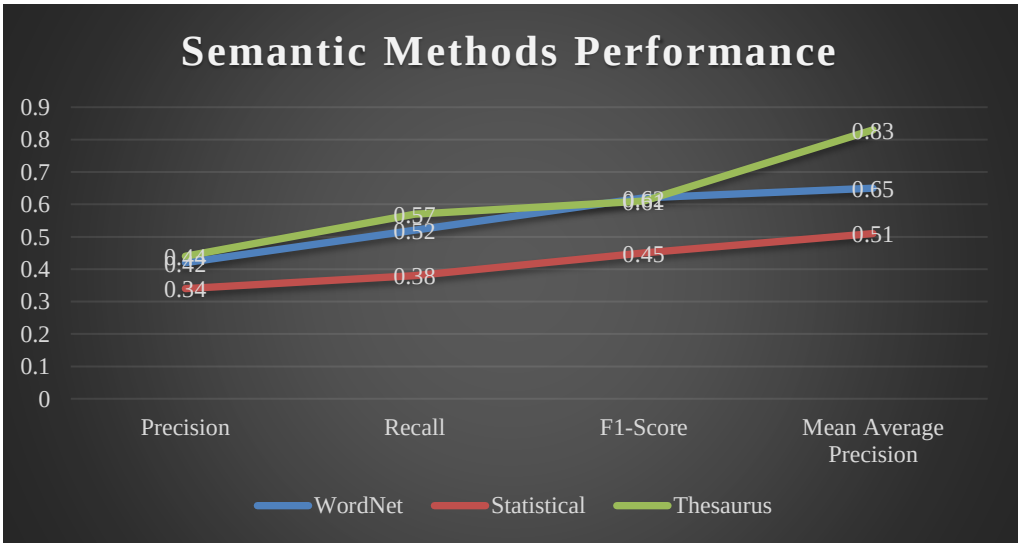

Fig. 6: Semantic Methods Performance

This Fig. 6 comparative study has been conducted on three semantic similarity methods (WordNet, Statistical, and Thesaurus) with respect to their Precision, Recall, F1-Score, and Mean Average Precision (MAP) in the figure provided above. The value of the retrieved data, particularly in multimedia information retrieval (MIR), which enhances the

relevance retrieval of information based on underlying concepts, is evaluated at a deeper level with the help of these metrics. The Thesaurus approach shows the best results in every evaluation metric and has the highest MAP of 0.83, which implies that it is best suited for ranking relevant results in multiple queries. Further, it has good Recall values of 0.57 and an F1 Score of 0.61, demonstrating that it is capturing appropriate items. With these results, we conclude that Thesaurus-based semantic similarity approaches capture more significant relationships in multimedia content elements. Attributable to a wider structured lexical database, the WordNet-based method displays consistent performance with a MAP of 0.65, ranking second to the Thesaurus Method. Additionally, he demonstrates propitious results in Recall and F1 metrics, proving that his interpretation of semantic relationships is valid and effective. In the meantime, the Statistical approach performs the lowest across all metrics, with the lowest precision and F1-score of 0.34 and 0.45, respectively. This suggests that mere reliance on co-occurrence statistics or frequency-based measures does not capture the richness of meaning required for more advanced information retrieval systems. To conclude, the Graph illustrates that Thesaurus-based semantic similarity measures outperform the other two methods in both coverage and accuracy. Also, WordNet offers a reasonably reliable and organized system to counter this; however, statistical measures are poor at capturing delicate relationships. Because this study seeks to answer the question, "What methods or techniques are most suitable for semantic similarity estimation in the design or enhancement of multimodal information retrieval systems?", this study will explain how this comparison can aid in the selection of semantic similarity approaches in designing or refining MIR systems.

V. Conclusion

The current study analyzed the effectiveness of three approaches towards semantic similarity— WordNet, Statistical, and Thesaurus-based methods— in relation to multimedia information retrieval (MIR). A performance evaluation study using core metrics of MIR systems, including Precision, Recall, F1-Score, and Mean Average Precision (MAP), revealed that Thesaurus-based methods had the highest effectiveness in all measures compared to the other two methods. These results imply that manually maintained semantic resources are best for capturing deep conceptual relationships within the multimedia content. Even though portions of the WordNet-based methods yielded competitive outcomes, particularly in F1-Score and MAP, there was a determinable lack of flexibility stemming from the predefined lexical structure. Moreover, despite boasting the more favorable computational cost associated with Statistical methods, these methods' reliance on co-occurrence data on surface-level retrieval tasks resulted in diminished depth of semantics. This highlights the relationship between semantic depth and domain specificity and effectiveness in MIR systems. With this in mind, future work should consider developing hybrid solutions combining the semantic accuracy utilizing Thesaurus and WordNet with statistical approaches, incorporating machine learning or deep learning to add robustness. These hybrid models may provide a more optimal approach that is efficient in the retrieval of multimedia data and accuracy. In the end, this research underlines the need for the integration of semantics into the clustering and retrieval methods in MIR systems as the core structure of intelligent systems becomes more sophisticated and diverse.

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