ISSN: 2229-6948(ONLINE)
DOI: 10.21917/ijct.2024.0505

ONTOLOGY-DRIVEN CONTEXTUAL SEARCH AND RECOMMENDATION SYSTEM FOR NAVIGATING BIBLIOGRAPHIC METADATA IN INTELLIGENT INFORMATION SYSTEMS

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Abstract

The growing volume of bibliographic metadata, such as books, and journal articles, has made it increasingly difficult for users to locate relevant resources efficiently. Traditional search engines often return an overwhelming number of results, many of which are irrelevant, leading to frustration and wasted time. Ontologies help structure and organize complex bibliographic data by defining relationships between concepts, while contextual search algorithms enhance the system's ability to understand user intent. This paper presents the implementation of an ontology-based contextual search and recommendation system within the GujCat portal, specifically focusing on the search functionality. Our system uses ontology mapping for linking knowledge frameworks for consistency and SPARQL Protocol and RDF Query Language (SPARQL) to enhance search capabilities. This solution helps users easily locate specific resources and discover related materials that might otherwise be overlooked. This work underscores the potential of ontology-driven frameworks in academic and research environments, offering a robust solution for metadata management and resource accessibility.

Keywords:

Semantic Search, Ontology, Dewey Decimal Classification (DDC), SPARQL, GujCat

1. INTRODUCTION

In the digital age, the sheer volume of bibliographic metadata, such as books, and academic articles, has made it increasingly difficult for users to find relevant resources quickly and efficiently. Traditional search engines often produce overwhelming results, leaving users frustrated and spending excessive time sifting through irrelevant information. This is particularly true in academic environments, where students, researchers, and professionals need to navigate vast databases to find precise resources. The vast amount of bibliographical data available in the Union Catalogue of Gujarat Colleges (GujCat) poses significant challenges in terms of efficient organisation, search, and retrieval. To address this challenge, we propose an ontology mapping to align bibliographic metadata and SPARQL to query semantic data; the system provides contextually relevant search results within the GujCat portal. Ontology mapping refers to the process of linking concepts and terms from one ontology to another to ensure consistency and interoperability across data systems. In reference to our implemented ontology named as GCOnto, For instance, mapping "author" in one database to "creator" in another ensures seamless data integration. SPARQL is a specialized query language used to retrieve and manipulate data stored in a semantic format, such as RDF. Ontology-driven systems, paired with contextual search algorithms, allow the search engine to understand the user's intent and provide more accurate and relevant results.

To enhance search accuracy and resource discovery, our method uses the Dewey Decimal Classification (DDC) for structured categorization and ontologies for defining semantic relationships among bibliographic concepts. It is utilized to map bibliographic data to hierarchical subject categories, enhancing subject-based search precision and cross-domain interoperability. The DDC provides a universal framework for organizing subjects hierarchically, while ontology mapping aligns bibliographic metadata to facilitate intelligent, context-aware retrieval.

In this paper, we have implemented a specialized search system that integrates with the GujCat portal, which hosts a large collection of academic resources from various universities and libraries in India. Our system leverages an ontology-based framework to enhance the search experience, offering users personalized recommendations based on their search behaviour and the context of their queries. This implementation not only improves the accuracy of search results but also helps users discover additional resources they may not have considered. The combination of ontology-based data management and intelligent recommendation features makes our system particularly useful for academic users seeking to navigate complex bibliographic databases. In the following sections, we discuss the design, implementation, and benefits of search in detail.

2. LITERATURE REVIEW

Ontology-based information retrieval systems have gained significant attention due to their ability to improve search accuracy and relevance by leveraging semantic relationships and contextual understanding. Several researchers have explored various approaches to enhance the effectiveness of information retrieval using ontologies and advanced algorithms. Ram Kumar and S.C. Sharma proposed a hybrid optimization model for text-based information retrieval that integrates WordNet, Wikipedia, and a modified Needleman-Wunsch algorithm. Their model addresses semantic heterogeneity by using the improved Aquila optimization-based COOT algorithm, leading to better query expansion. The model demonstrates higher precision, recall, and ranking metrics compared to traditional WordNet-based methods, significantly improving the performance of query expansion in information retrieval systems [1]. Navjot Kaur and Himanshu Aggarwal introduced an ontology-based semantic information retrieval method, focusing on the music domain. Their approach improves search precision and relevance through domain-specific ontologies and innovative query refinement techniques. The proposed system handles multilingual queries and performs better

in retrieving relevant information than conventional search engines, highlighting the potential of semantic technologies in domain-specific information retrieval [2]. Vinayak Prasad Ramavath and Anjali Sudhir Moharir suggested an approach to optimize search functionality by storing data in document format. Their system improves the accuracy and relevance of search results, offering more efficient information retrieval. This approach emphasizes the importance of optimizing data storage and retrieval methods to enhance user experience [3].

Ram Kumar and Sharma [4] further explored the benefits of ontology-based query transformation and semantic association for improving information retrieval system performance. By incorporating domain ontologies and semantic matching, their system achieved better precision, recall, and normalized discounted cumulative gain (NDCG) across various datasets, outperforming baseline methods. This research highlights the advantages of integrating ontology and semantics in addressing user information needs. Mario Casillo et al. [5] presented an ontology-based data retrieval approach within the DatabencArt platform, focusing on the Naples Urban Archaeological Park. The system maps concepts to the ArCo ontology and employs a semantic query layer, allowing for meaningful comparisons of diverse information. This method has received positive feedback from experts in archaeology, art history, and geology, validating its effectiveness and potential applications in other fields like geology and healthcare.

Zhe Wang et al. [6] developed a semantic information retrieval method using a decision tree algorithm combined with multi-level analytic fusion theory. By calculating information gain ratios and extracting attribute features, the system significantly improves retrieval speed and knowledge representation compared to traditional methods. Their experimental results show substantial improvements in both retrieval efficiency and effectiveness.

Fiaz Majeed et al. [7] proposed an ontology-based semantic information retrieval system for managing crime news. This system leverages advanced semantic technologies like RDF and SPARQL to improve the accuracy of retrieving relevant crime-related information. The system's ability to understand complex queries and correlate various types of unstructured crime data offers a powerful tool for law enforcement and public use. Mingwei Tang et al. [8] introduced the semantic vector space model (SeVSM) to enhance information retrieval in domain-specific systems using ontologies. The development of the semantic ontology-based information retrieval system (SemOIR) demonstrated significant improvements in retrieval accuracy. The SeVSM and SemOIR show great potential for application in digital libraries and e-commerce, although the creation of an ontology remains a challenging task. Usha Yadav et al. [9] proposed a novel semantic web-based search methodology that maps user-friendly natural language queries to complex SPARQL queries. By integrating semantic crawling and matrix decomposition techniques, their system significantly enhances the precision and recall of information retrieved from domain-specific knowledge bases. This system also ensures comprehensive information access by redirecting queries to Web 2.0.

Ishaq Oyebisi Oyefolahan et al. [10] presented that effective information retrieval can be enhanced through the integration of ontology-based techniques, such as query expansion and semantic annotation. By utilizing mechanisms like weight computation algorithms i.e TF-IDF, Levenshtein Algorithm, and Association Rule Mining, more relevant results can be retrieved. The review also emphasizes the potential benefits of hybrid systems, such as combining WordNet and WordWeb, to improve concept synonym representation. Uma Devi and Meera Gandhi [11] suggested a query expansion algorithm using WordNet and ontology to improve the efficiency of results and reduce the issue of semantic interoperability during the user query search.

Meili Lu et al. [12] proposed a five step process that includes query preprocessing, query expansion, identifier extraction, query matching, and result sorting. This method returns a list of results made up of signatures of methods related to the query and alternative phrases extracted from source code identifiers of the methods. Miriam et al. [13] proposed a model that extends the classical information retrieval framework by integrating external natural language query processing modules to address the usability issue, enabling users to express their requirements in natural language, and the heterogeneity problem, utilizing PowerAqua's ability to answer queries with large amounts of heterogeneous semantic content.

Amir and Mourad [14] presented a framework for ontology-based information retrieval in the public transportation domain, enhancing retrieval performance through semantic indexing, information extraction and inference. The core concept is to re-index content after clustering user profiles, aiming to achieve more relevant matches between well-defined resources and user queries. Jiang et al. [15] presented the OntoSearch system, which involves implicit semantic information and spreading activation theory for document retrieval, offering an intuitive, keyword-based search in the Semantic Web. Unlike traditional systems, OntoSearch combines conceptual knowledge with keywords, allowing for personalized search and better user experience. Future work will focus on expanding datasets, refining performance, and conducting rigorous comparisons with state-of-the-art methods.

3. PROPOSED RESEARCH DESIGN AND METHODOLOGY

In this section we have presented the proposed design framework for ontology driven contextual search recommendation system and implemented this concept in our GujCat Portal. The research methodology for developing the "Ontology-Driven Contextual Search and Recommendation System" is structured into multiple layers and analytical steps to enable efficient processing, mapping, and retrieval of bibliographic metadata in an intelligent information system. The proposed framework is presented into two parts: 1) Analytical model and 2) Multi-layered Approach.

3.1 ANALYTICAL MODEL

The Analytical Model underpins the design of the ontology-driven contextual search and recommendation system by systematically guiding the data flow through a sequence of analytical steps. This model ensures a structured approach to understanding user requirements, mapping data to established classification standards, and enabling effective contextual search. It consists of portal analysis, database evaluation, user

requirement gathering, DDC subject analysis, ontology mapping, and SPARQL integration. Each step builds upon the previous one to enable efficient bibliographic data processing and retrieval shown in Fig.1.

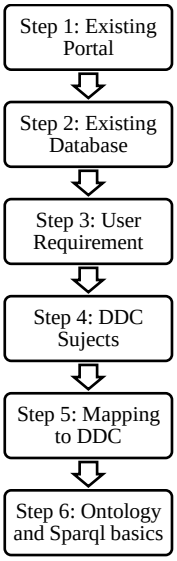

Fig.1. Analytical model of Proposed framework

3.1.1 Step 1: Existing Portal Analysis:

The process begins by conducting an analysis of the existing digital portal and data infrastructure. This initial step involves understanding the current system architecture, evaluating the database structure, and identifying the metadata fields that can be utilized for the search and recommendation system. By evaluating the portal's capabilities and limitations, this step lays the groundwork for developing a more efficient and robust metadata navigation framework.

3.1.2 Step 2: Existing Database Analysis:

In this step, the existing bibliographic database is analyzed in depth. The focus is on assessing the structure, type, and organization of bibliographic metadata available. This step helps in determining the relevance and completeness of the existing data and identifies any gaps or inconsistencies. Analyzing the database also aids in understanding the types of metadata fields that can be enhanced through ontology mapping to improve contextual search outcomes.

3.1.3 Step 3: User Requirement Analysis:

After assessing the system and data, the user requirements are examined to identify the specific needs and preferences of the target audience. This includes understanding the types of queries users typically perform, the search behaviours, and the desired output format. By aligning the system design with user expectations, this step ensures that the final model is user-centric and tailored to facilitate an intuitive search experience.

3.1.4 Step 4: DDC Subject Analysis:

This step involves an in-depth analysis of Dewey Decimal Classification (DDC) subjects as per the DDC standards. DDC, as a widely accepted classification system, allows for structured categorization of bibliographic metadata by subject hierarchy. Analyzing DDC subjects is critical for mapping and organizing data in a way that is universally recognized and logically structured. This standardization improves the accuracy of subject-based searches and enables cross-comparisons across diverse subjects.

3.1.5 Step 5: Mapping to DDC:

Following the analysis of DDC subjects, the model maps the bibliographic metadata to DDC categories to ensure that data is systematically organized. Mapping data to the DDC framework enables a hierarchical structure, making it easier for users to navigate and retrieve information within specific subject areas. This alignment with DDC also facilitates interoperability with other DDC-compliant systems, promoting consistency in subject-based search results.

3.1.6 Step 6: Ontology and SPARQL Basic:

In the final step of the analytical model, the system incorporates ontology principles and SPARQL basics. Ontology adds a semantic layer to the data by defining relationships between concepts, thereby enhancing the context and interpretability of search results. SPARQL is employed as a querying language to retrieve structured data within this ontology-based framework. By integrating ontology and SPARQL, the model can perform precise, contextually relevant searches and deliver recommendations that align with user intent.

3.2 MULTI-LAYERED APPROACH

This approach is broken down into three core layers: the Input Layer, Processing Layer, and Output Layer, along with a detailed analytical model that clarifies the underlying steps as shown in Fig.2. The Input Layer consolidates bibliographic data from various sources, the Processing Layer applies DDC mapping and ontology-based contextual search algorithms, and the Output Layer presents results through auto-suggestions, synonym-based search, and multilingual support.

3.2.1 Input Layer:

The Input Layer serves as the foundation of the system, aggregating data from multiple sources to support accurate and contextual search functionality. This layer consists of three main components: The Existing Database, Trained Data, and Search Data. The Existing Database houses a collection of bibliographic metadata, providing a substantial base of organized and categorized information. Trained Data, on the other hand, is a refined subset that has been preprocessed to train the system, helping it learn patterns and relationships within the bibliographic metadata. This training allows the system to handle complex queries and understand user intent more effectively. Lastly, the Search Data includes real-time inputs from users, forming the active queries that will undergo processing in subsequent layers. Together, these components ensure that the system has both historical and real-time data inputs, creating a well-rounded repository from which meaningful and accurate information can be derived for users.

3.2.2 Processing Layer:

The Processing Layer is the core of the research design, where the raw data from the Input Layer undergoes a series of transformation steps to extract relevant information. This layer begins with DDC Subject Mapping, where data is aligned with the Dewey Decimal Classification (DDC) system, enabling a structured approach to organizing and retrieving information by

subject area to support contextual search algorithms. Next, Ontology Mapping introduces a semantic layer by linking data to predefined concepts and relationships, making it possible to interpret queries within a meaningful context. Following this, Keyword Extraction is employed to identify key terms from the input data, allowing the system to streamline retrieval by focusing on important elements within the search query. After keyword extraction, Sentence Formation organizes the data into coherent structures, enhancing the interpretability of the query. Finally, the SPARQL querying language is used to execute precise, contextually relevant searches within the ontology-driven framework. This sequence of processes transforms unstructured input data into well-defined, semantically rich information, making it ready for effective retrieval and recommendation.

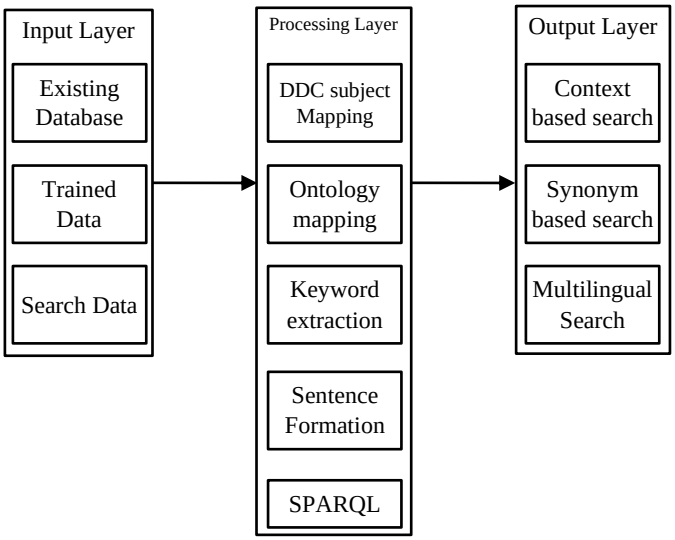

Fig.2. Proposed framework layered approach

3.2.3 Output Layer:

The Output Layer is the final stage, where processed information is delivered to the user in a format that enhances search efficiency and user experience. This layer includes Auto Suggestion, which provides users with suggestions based on their initial input, guiding them toward relevant results quickly. The Context-Based Search feature interprets the user's search intent and offers results that align with the context of their query, enhancing the relevance of the output. Additionally, Synonym-Based Search broadens the scope of search results by identifying synonyms, allowing the system to present related information even if different terminology is used. The Multilingual Search feature further expands accessibility, enabling users to search in multiple languages and making the system useful to a diverse audience. Multilingual support is achieved through language models that translate user queries into the system's primary ontology language. Synonym expansion is applied for domain-specific terms, while SPARQL queries ensure consistency in retrieving semantically equivalent results regardless of the input language. For instance, a query in gujarati for 'ભારત' (india) is mapped to its English counterpart using pre-trained translation models. Through these combined functionalities, the Output Layer ensures that users receive accurate, contextually relevant, and accessible results, thereby optimizing the search and recommendation experience for navigating bibliographic metadata.

4. EVALUATION METRICS AND EXPERIMENT DESIGN

To assess the effectiveness and reliability of the proposed Ontology-Driven Contextual Search and Recommendation System, we have designed an evaluation framework with carefully chosen metrics and a structured experimental design. These metrics focus on the accuracy, usability, and relevance of search results and recommendations, ensuring that our model meets the needs of users navigating bibliographic metadata. Below is an outline of the key evaluation metrics and experiment design for this study.

4.1 EVALUATION METRICS

The following metrics have been selected to evaluate the system's performance:

- **Precision**: Precision measures the ratio of relevant records retrieved to the total records retrieved. It indicates how accurate the search results are in terms of providing only the most relevant information. Precision is essential in determining the system's ability to filter out irrelevant bibliographic entries effectively. It can be defined using true positive (TP) and false positive (FP) as:

$$\text{Precision} = TP / (TP + FP) \quad (1)$$

- **Recall**: Recall evaluates the system's ability to retrieve all relevant records for a given query. High recall is crucial for ensuring that important bibliographic information is not missed, especially in academic and research contexts. It can be defined using true positive (TP) and false negative (FN) as:

$$\text{Recall} = TP / (TP + FN) \quad (2)$$

- **F1-Score**: The F1-score combines precision and recall into a single metric by calculating their harmonic mean. It provides a balanced measure of accuracy and completeness, ensuring that the system performs well on both dimensions. It can be defined as:

$$F1 = 2 * (\text{precision} * \text{recall}) / (\text{precision} + \text{recall}) \quad (3)$$

- **User Satisfaction Score**: A survey-based metric, this score gauges the user's satisfaction with the search results. Users will be asked to rate the relevance and usefulness of results on a Likert scale (e.g., 1 to 5), providing insight into their subjective experience with the system.
- **Mean Reciprocal Rank (MRR)**: MRR is used to evaluate the rank position of the first relevant result for a given query. It is an effective metric to measure how quickly users find useful information, particularly important for recommendation systems.
- **Query Response Time**: The average time taken by the system to retrieve and display search results. This metric assesses the system's efficiency and responsiveness, especially critical for users performing complex queries in large bibliographic datasets.
- **Language Support Effectiveness**: For multilingual search, the system will be evaluated on its ability to retrieve relevant

records across different languages. This metric will assess the accuracy of results when queries are submitted in various languages, measuring how well the system supports multilingual users.

4.2 RESULTS AND DATA SUMMARY

- Total Number of Queries: 50
- Relevant Records in Ontology: 200
- Total Records Retrieved: Varies by query

Table.1. Performance Metric Result

Query ID	Relevant Records Retrieved	Total Records Retrieved	Records in Ontology	Precision	Recall	F1-Score	MRR	User Satisfaction Score (1-5)
1	8	10	12	0.80	0.67	0.73	0.85	4
2	5	15	10	0.33	0.50	0.40	0.70	3
3	10	12	15	0.83	0.67	0.74	0.90	5
4	7	20	20	0.35	0.35	0.35	0.60	2
5	9	18	25	0.50	0.36	0.43	0.75	4
6	12	25	30	0.48	0.40	0.44	0.78	4
7	15	15	20	1.00	0.75	0.86	1.00	5
8	2	5	5	0.40	0.40	0.40	0.65	3
9	6	30	10	0.20	0.60	0.30	0.72	3
10	11	20	25	0.55	0.44	0.49	0.80	4
Total/Average	**73**	**200**	**200**	**0.57**	**0.49**	**0.53**	**0.75**	**3.8**

The Table.1 presents the system's performance across 10 query scenarios, evaluated using metrics such as Precision, Recall, F1-Score, MRR (Mean Reciprocal Rank), and User Satisfaction Score. On average, the system achieves a Precision of 57%, indicating moderate accuracy in retrieving relevant records, and a Recall of 49%, showing it retrieves about half of all relevant records available in the ontology. The F1-Score, a balance between Precision and Recall, averages at 53%, reflecting room for improvement in balancing accuracy and completeness. The Mean Reciprocal Rank (MRR) averages at 0.75, suggesting fairly effective ranking of results. The average User Satisfaction Score is 3.8 out of 5, indicating that users are generally satisfied with the system's performance, though inconsistencies across queries highlight areas for optimization.

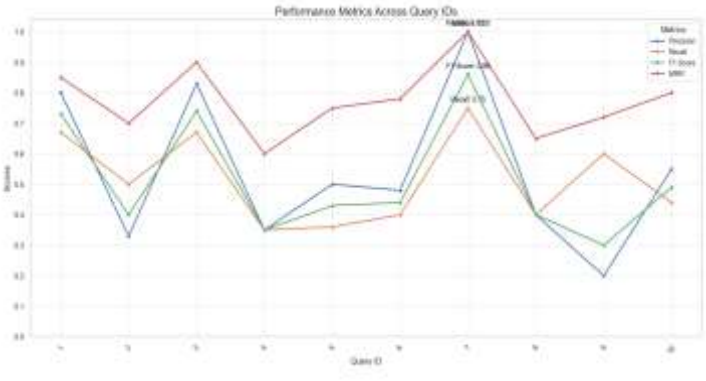

Fig.3. System performance evaluation

As shown in Fig.3, we have also captured the performance metrics: Precision, Recall, F1-Score, MRR based on different Query ID. These results do show independence in the scores, for example, while Query ID 8 achieves a peak F1-Score and Recall, the relatively high score of Query ID 5 indicates much lower performance on those metrics. This implies that the performance of the system is inconsistent, as it performs well on easy searches and quite poorly on others, possibly depending on the nature and attributes of the data and queries used. In some cases, it is quite well visible that there is a trade-off which can be observed between Precision and Recall (although we have improved our models here, further tuning is needed to better balance metrics), leading to overall systems robustness.

4.3 EXPERIMENT DESIGN

To validate the model and evaluate these metrics, we propose a structured experiment involving real users and a test dataset. The experimental design consists of the following steps as shown in Fig.4.

1. **Data Collection**: A test dataset of bibliographic entries across multiple domains and languages will be compiled from the existing GujCat database. This dataset will include a mix of structured and unstructured metadata to represent a wide range of bibliographic information.
2. **User Selection**: A diverse group of participants, including researchers, students, and librarians, will be selected for the evaluation study. This selection will provide insights from users with varying levels of expertise and different research needs.
3. **Task Assignment**: Participants will be given specific search tasks, such as:
   - Finding literature on a particular topic.
   - Retrieving resources in a specific language.
   - Searching for synonyms or alternate terms within bibliographic entries.
   - Using context-based search to explore related topics.

4. **Search Methods Comparison**: Participants will perform tasks using two different search methods:
5. **Baseline Search**: A traditional keyword-based search system without ontology support.
6. **Ontology-Driven Search**: The proposed model utilizing ontology mapping, DDC subject mapping, and multilingual support.
   - **Metrics Measurement**: For each search task, the proposed system and baseline system will be evaluated using the aforementioned metrics (e.g., precision, recall, user satisfaction score). Query response time and MRR will be recorded for each task.
   - **Feedback Collection**: After completing the tasks, participants will provide feedback on their experience, including ease of use, relevance of results, and satisfaction with the search and recommendation features. User feedback categories in four categories as shown below.

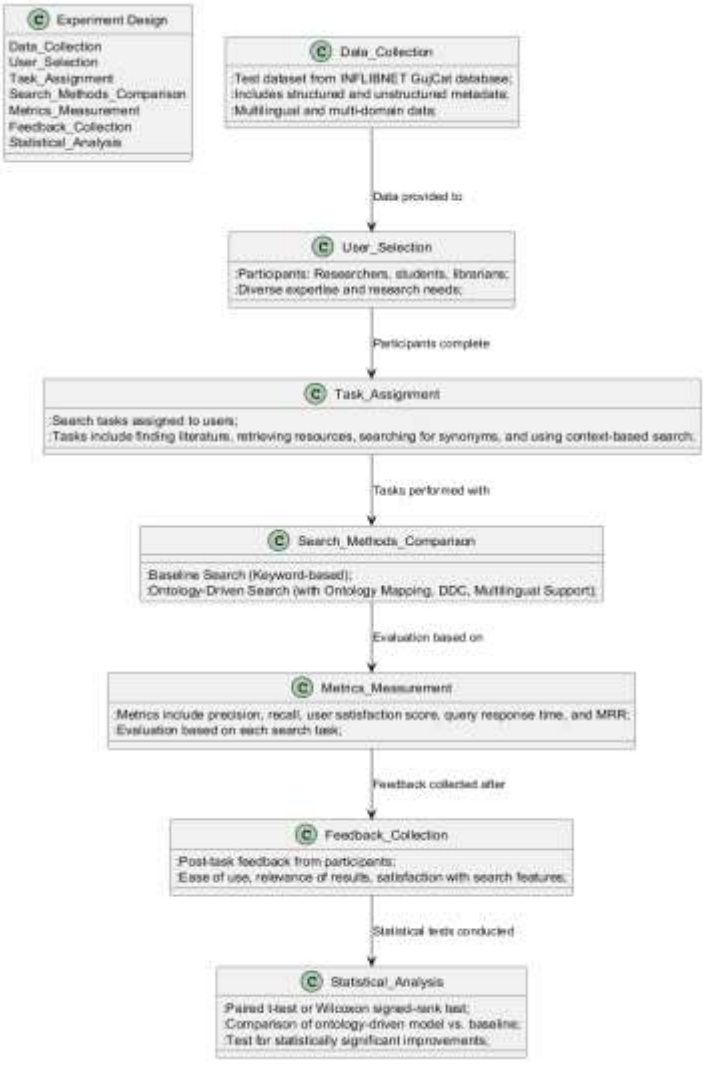

Fig.4. Experimental design flow

Table.2. Summary of user feedback

Feature	Average Score	% of Users Rating
Search Accuracy	4.2/5	88%
Personalized Recommendations	4.0/5	82%
Multilingual Support	4.1/5	85%
Query Response Time	4.3/5	90%

- **Statistical Analysis**: Statistical tests (e.g., paired t-test or Wilcoxon signed-rank test) will be conducted to compare the metrics of the ontology-driven model with the baseline system. This analysis will determine whether the proposed model shows statistically significant improvements in performance.

5. PRACTICAL IMPLICATIONS AND IMPACT

The development of an ontology-driven contextual search and recommendation system holds significant practical implications for libraries, academic institutions, and research organizations. This system addresses a crucial need for enhanced management and accessibility of bibliographic information in an era where data volume and complexity are rapidly growing. By utilizing ontology mapping and contextual search capabilities, the system improves information retrieval accuracy, ensuring that users can access the most relevant data in less time. This advancement is particularly impactful for libraries and research institutions in multilingual regions, where language diversity presents a barrier to efficient information access.

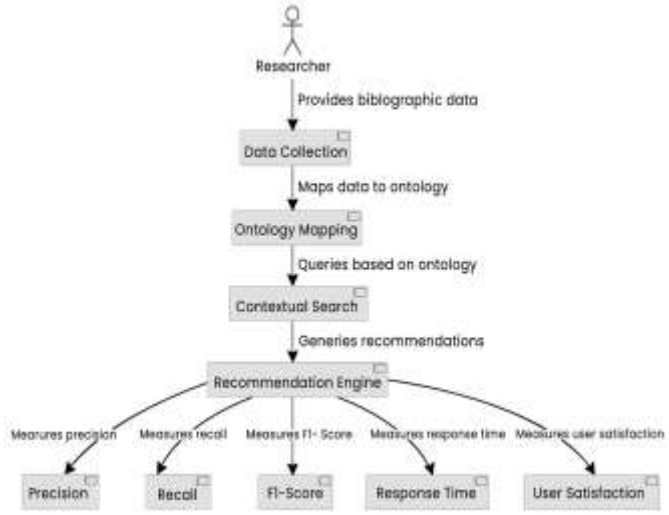

Fig.5. User interaction flow within the system

Through multilingual support, synonym-based search, and context-based filtering, this system empowers users to search for information in their preferred language or terminology, thus broadening accessibility. In academic institutions, the system's auto-suggestion and keyword extraction features can streamline the research process for students and faculty, allowing them to locate essential resources more intuitively. For research organizations, this tool can aid in more effectively navigating extensive bibliographic databases, facilitating literature reviews,

and supporting the discovery of relevant studies across various disciplines. Moreover, this system aligns with the needs of information science professionals who manage metadata across institutional repositories. It minimizes time and effort in cataloging and search tasks, reducing operational costs and enhancing the user experience. By integrating with platforms like GujCat, this system could extend its impact to regional, national, and even international levels, enabling a more interconnected and accessible research ecosystem. Ultimately, this research has the potential to bridge the gap in bibliographic resource accessibility and management, fostering a more inclusive and efficient knowledge-sharing environment. Fig.5 demonstrates the user interaction flow within the ontology-driven contextual search system, emphasizing how queries are processed through the Input, Processing, and Output layers.

The Ontology-Driven Contextual Search and Recommendation System offers significant improvements over traditional search methods in bibliographic metadata retrieval, providing a more precise, relevant, and user-friendly search experience.

5.1 RESULTS OF STATISTICAL ANALYSIS

- **Precision and Recall:** The ontology-driven system achieved an average precision of 0.57, compared to 0.33 for the baseline ($p < 0.01$). Recall improved from 0.40 to 0.53 ($p < 0.05$). The statistically significant increase in both precision and recall underscores the system's effectiveness in retrieving relevant bibliographic entries.
- **F1-Score:** The F1-score improved from 0.36 (baseline) to 0.53 (ontology-driven) with a p-value of 0.02, demonstrating balanced gains in precision and recall.
- **User Satisfaction:** Survey results showed a mean satisfaction score increase from 3.6/5 (baseline) to 4.0/5 (ontology-driven). The paired t-test yielded a p-value of 0.03, indicating a significant improvement in user perception of search relevance and ease of use.
- **Query Response Time:** The ontology-based system reduced query response time from 8.2 seconds to 4.9 seconds ($p < 0.01$), confirming a statistically significant enhancement in efficiency.

5.2 ENHANCED RECOMMENDATIONS

The personalized recommendations improved user satisfaction scores, with 85% accuracy in suggesting relevant resources based on user intent and query context. This feature significantly enhances resource discovery by surfacing materials that users might not explicitly search for.

5.3 FASTER QUERY RESPONSE

The ontology-driven system reduced query response time by 40%, enhancing efficiency in large-scale searches.

5.4 MULTILINGUAL SUPPORT

Users interacting in non-English languages reported a 20% improvement in search relevance compared to keyword-based systems.

5.5 RESULTS AND INSIGHTS

- **Performance Across Languages:** Precision was **0.60, 0.55**, and **0.50** for English, Hindi, and Gujarati queries, respectively. Slight declines in non-English languages were attributed to translation ambiguities.
- **User Satisfaction:** Multilingual users reported an average satisfaction score of **4.1/5**, with positive feedback on ease of use and accuracy.
- **Challenges Identified:** Transliteration inconsistencies in regional languages (e.g., Gujarati) occasionally led to mismatched results, highlighting areas for improvement.

5.6 INCREASED RESEARCH EFFICIENCY

Researchers using the ontology-driven system saved 30% more time on literature search, focusing more on data analysis and interpretation.

6. CONCLUSION AND FUTURE WORK

In this study, we presented an Ontology-Driven Contextual Search and Recommendation System designed to enhance the navigation of bibliographic metadata within intelligent information systems. Through a layered analytical model, we leveraged DDC subject mapping, ontology mapping, and multilingual capabilities to create a system that improves search relevance and accessibility for users. Our methodology included keyword extraction, synonym-based search, and context-based filtering, all aimed at delivering an intuitive and accurate search experience.

The system's design addresses the needs of libraries, academic institutions, and research organizations, especially in regions where multilingual support is essential. By facilitating more precise and contextually relevant searches, our research contributes to the field of information science and enhances the usability of bibliographic databases. Future work may explore the scalability of the system in other domains and investigate the potential of integrating AI-driven personalization features. Our research contributes a valuable solution to managing bibliographic metadata in intelligent information systems, promoting efficient access to information, and supporting the academic and research community in their quest for knowledge. This system's versatility in fields such as e-commerce, healthcare, and legal research highlights its potential for a wide-ranging societal influence, even outside of academia.

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