

ENHANCING LEGAL CASE RETRIEVAL IN MOROCCAN INSOLVENCY LAW USING ONTOLOGY

KAOUTAR BELHOUCINE¹, NADIA ZAME²

MOHAMMED MOURCHID³, ABDELAZIZ MOULOUDI⁴

MISC Laboratory, Faculty of Science, Ibn Tofail University, Kénitra, Morocco

E-mail: ¹kaoutar.belhoucine@gmail.com, ²nadia.zame@uit.ac.ma

³mourchidm@hotmail.com, ⁴mouloudi_aziz@hotmail.com

ABSTRACT

Retrieving relevant legal cases from digital publications of Moroccan jurisprudence remains a challenge due to the complex nature of the information and the vastness of the database. This research introduces an enhanced Case-Based Retrieval (CBR) system, leveraging ontologies to streamline the retrieval process. The hierarchical structure and logical reasoning capabilities of ontologies enable a comprehensive understanding of semantic relationships. Implementing our system, which combines ontologies with a CBR approach, has demonstrated over 80% accuracy across three legal datasets. This innovation significantly improves the precision of legal case retrieval for Arabic Moroccan jurisprudence.

Keywords: *Legal Retrieval; Moroccan Insolvency Law; Ontologies Building; Case Based Retrieval; Arabic Text.*

1. INTRODUCTION

Given the global interconnectedness and the frequent international implications of legal decisions, an ever-growing demand for efficient legal information retrieval is evident. However, the legal field is inherently complex due to its specialized knowledge and unique vocabulary. Some terms hold no meaning outside the legal context, while others may carry both legal significance and common-sense meanings [1]. The repercussions of inaccurate or incomplete information can lead to severe miscarriages of justice or protracted, resource-intensive litigations. Conventional retrieval systems reliant on keyword matching struggle to address the intricacies of legal terminology due to their lack of semantic understanding. Consequently, these systems may unintentionally disregard crucial information [2].

Researchers have recognized these challenges and focused on utilizing legal ontologies as a promising solution. Indeed, ontologies provide a formal and explicit way to represent shared conceptualization. When integrated into Case-Based Reasoning (CBR) systems [3], they can significantly aid in understanding the context of the current legal problem, drawing connections to similar cases

from the past, and, ultimately, suggesting viable solutions.

A significant development emerged in early 2023 with the digitization of Moroccan legal cases, available on the Moroccan justice portal 'Adala' [4]. This digitization provides a rich database that offers ample opportunities for developing and testing semantic search systems based on legal ontologies.

Motivated by the recognized challenges within the domain, the disponibility of legal resources, and the potential benefits of utilizing ontologies, this paper introduces the Moroccan Legal Case Retrieval System (MLCRS). The proposed system places significant focus on researching case representation in the form of ontology to augment knowledge-intensive CBR processes and support semantic retrieval.

The rest of the paper is organized as follows: Section 2 provides a comprehensive review of relevant literature, summarizing previous works and identifying gaps this research aims to address. Section 3 highlights the primary contributions of this study, focusing on the ontological framework used for case representation. To gain a deeper understanding of the proposed MLCRS, Section 4 explains the retrieval approach, database design, and query processing. In Section 5, we analyze the performance of the suggested system. The paper

concludes with Section 6, which reviews the study's findings, discusses their implications, and suggests directions for future research.

2. LITERATURE REVIEW

2.1 Related Work

Various domains have benefited from incorporating ontologies and case-based reasoning (CBR). Our focus is primarily on practical implementations, providing insights to guide the creation of an ontological case-based retrieval system for the Moroccan legal domain. For enhanced clarity, Table 1 presents a comprehensive comparison of each work's contributions, limitations, and potential future directions.

2.1 Review

In the study conducted by [5], an ontology-based communication architecture was proposed for a distributed case-based retrieval system for architectural designs. The researchers pioneered an innovative way to leverage ontologies to improve communication between system components. Despite the novelty, the study was limited in its scope to architectural designs and lacked broad applicability across different domains.

The study [6] introduced an ontological Chinese legal consultation system. They

successfully demonstrated that ontologies could be efficiently utilized in the legal domain. However, the system was designed for the Chinese language, and there are complexities associated with porting it to Arabic or other languages, particularly in terms of semantics and linguistic structures.

In [7], researchers presented a case-based reasoning system that suggests data-cleaning algorithms for classification and regression tasks. Their work marked a significant advancement in enhancing the efficiency of data-cleaning algorithms. However, the system focuses only on data cleaning, and its potential for case retrieval remains unexplored.

The study [8] introduced an ontology-based CBR approach for personalized itinerary search systems in urban freight transport. Demonstrating the versatility of ontologies in personalization and planning, this study mainly revolves around transport systems. Translating its principles to legal case retrieval would demand further adaptations and testing.

The studies ([9]-[11]) proposed ontology-based models for various knowledge management and legal information tasks. Although these works underline the feasibility and efficiency of ontology-based approaches, the complexity of the legal domain, especially in Arabic, necessitates further exploration and a customized approach for efficient case retrieval.

Table 1: Comparison of the literature.

Reference	Contribution	Limitation	Method	Future Direction
[5]	Explored an ontology-based communication architecture for architectural designs retrieval	Focused on architectural designs	Case-Based Retrieval System	Potential application in other domains
[6]	Proposed an ontological Chinese legal consultation system	Specific to Chinese legal system	Ontology + CBR	Enhance for multilingual and multicultural systems
[7]	Developed a CBR system for recommending data cleaning algorithms	Limited to data cleaning tasks	Case-Based Reasoning	Extension to other decision-making tasks
[8]	Implemented an ontology-based CBR approach for personalized itinerary search systems	Specific to urban freight transport	Ontology + CBR	Broaden application to various transportation systems

[9], [10]	Elucidated knowledge management model based on the enterprise ontology	Focused on enterprise structures	Ontology	Expansion to diverse organizational structures
[11]	Presented an ontological representation of legal information for crowdsourcing	Dependent on crowdsourcing	Ontology	Enhance for professional curation and update

2.3 Main Contributions

The reviewed literature clearly signifies the substantial potential of ontologies and CBR in various fields. However, The arena of semantic retrieval within the Moroccan legal domain, particularly in Arabic, remains untouched by prior research. This paper consequently heralds a pioneering endeavor in this sphere, with its salient contributions summarized as follows:

- The article posits a unique ontological structure dedicated to representing Arabic Moroccan insolvency cases. This novel framework marks a significant leap forward in enhancing the precision and accuracy of semantic retrieval in the Moroccan legal domain.
- Inherent within the design of the proposed ontological framework is its potential for scalability. It is envisioned to be easily extended and applied to any legal domain where statutory ontology is available. This adaptable feature signifies a broad impact and utility beyond the specific context of Moroccan insolvency law.
- The paper puts forth an integrative approach for retrieving similar legal cases, predicated upon the synergistic use of ontologies and CBR-driven mechanisms during case indexing and retrieval. This holistic methodology amalgamates the strengths of both ontologies and CBR to deliver an optimized, personalized, and semantic-rich case retrieval system.

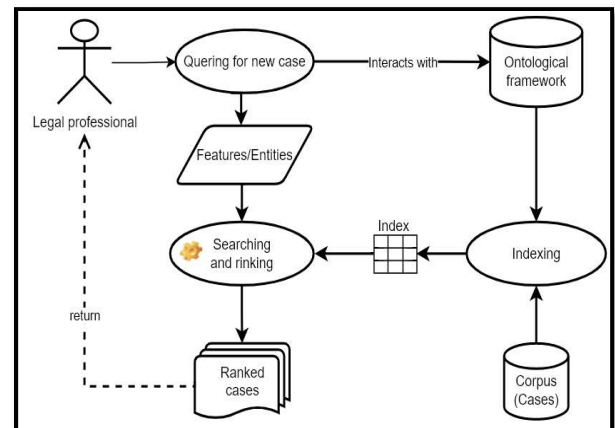
3. ONTOLOGY-SUPPORTED CASE-BASE RETRIEVAL SYSTEM

The Moroccan Legal Case Retrieval System (MLCRS) aims to utilize the context of the current legal problem to query and retrieve

similar cases from a structured legal database (as depicted in Figure 1). The system's core workflow consists of the following:

- Legal Corpus Indexing: Utilizes Natural Language Processing and semantic analysis techniques to construct a legal ontology, facilitating structured organization and categorization of legal cases.
- Feature Identification: The system extracts essential features from the given case, enabling query generation. This relies on an ontology-based extraction method.
- Similar Case Search: Advanced search algorithms are applied to find relevant cases based on the generated query. Methods such as nearest-neighbor search, induction and inference, knowledge-based indexing, analytic hierarchy process, and genetic algorithms can be employed [7].
- Case Ranking: The system ranks the retrieved cases based on their relevance to the input case.

Figure 1: The Overall Design Of The MLCRS



The MLCRS generates a ranked list of cases relevant to the input case, streamlining the legal professionals' analytical process.

3.1 Ontology Building

3.1.1 Corpus

Most existing AI experiments in law recognize that the body of legal knowledge is derived from formal law, including constitutions, codes, and regulations, as well as from case law precedents and experienced domain experts' interpretations [12][6]. Formal laws describe legal concepts qualitatively to make them more intuitive, while judicial cases provide a quantitative perspective and include many discretionary factors. Thus, we opted to constitute the corpus for developing the ontology framework from the two document categories. To provide a concrete illustration, we narrowed the scope of this article to insolvency law and its corresponding jurisprudence.

3.1.1.1 Moroccan insolvency law

Enacted in 2016 and outlined within the commercial code to regulate insolvency and bankruptcy proceedings in Morocco. It aims to provide mechanisms for preventing financial distress, rehabilitating financially troubled entities, and ensuring fair treatment of creditors and stakeholders in insolvency cases. An excerpt from this law appears in Figure 2.

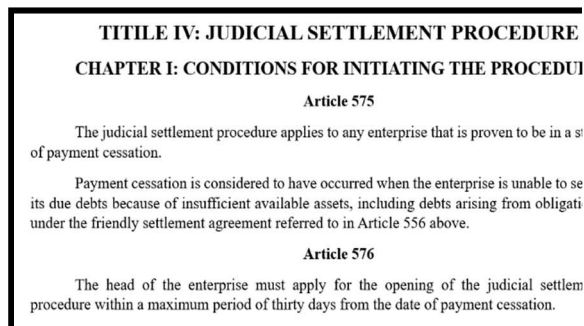


Figure 2: An excerpt from The Insolvency Law. The text is translated into English.

3.1.1.2 Jurisprudence

We possess 331 cases about insolvency proceedings from the court of cassation and 152 cases from the court of appeal. Our emphasis is on the court of cassation cases, chosen for testing suitability. While these cases adhere to a standard structure, their attributes can significantly differ based on legal subjects. Figure 3 presents a snippet of a case law related to insolvency proceedings.

3.1.2 Approach

In constructing the ontological model for Moroccan insolvency law, we adopted a top-down approach [13] collaborating with a legal expert to decipher the insolvency statutes and design the ontology. Further, we performed a bottom-up analysis [14] of judicial cases to identify influential factors and their correlations in insolvency cases. The ontology thus developed encompasses two subsets (Figure 4): the statutes ontology (Figure 5) and the cases ontology (Figure 6).

3.1.2.1 Statutes ontology

This ontology comprises three layers:

- Basic legal information layer includes the enacting authority, file number, release and implementation dates, and file class.
- Legal text classification layer, categorizing the law based on specific legal domains.
- Concrete legal information layer providing in-depth details of the legal text.

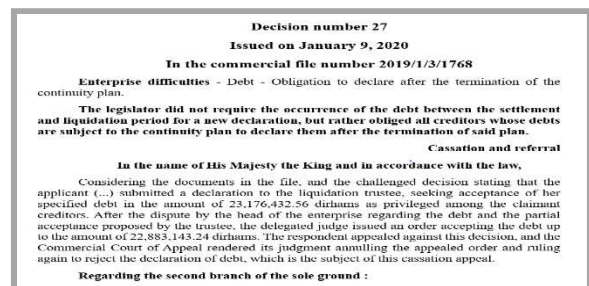


Figure 2: An Excerpt From Moroccan Legal. The Case Involves Insolvency, And The Text Has Been Translated Into English

The Moroccan insolvency law covers the following concepts: prevention, reorganization, settlement, liquidation, creditors' and debtors' rights, insolvency practitioners, and sanctions. An excerpt of the statutes ontology is shown in Figure 5.

3.1.2.2 Cases ontology

We took inspiration from existing case-based ontologies [15], [16] and identified five key components that describe the structure of Moroccan judicial cases:

- General data

- The principle of the case
- Background or context
- Legal reasoning
- The verdict

Through linguistic analysis using NooJ [17][18], an Arabic linguistic platform, and the EIDicAr Arabic dictionary [19], we extracted significant influencing factors in insolvency cases and classified them under six topics of interest.

We extracted terms based on syntactic patterns presenting the concepts of insolvency law from the statutes ontology, for example, *noun*, *noun-noun*, *noun-adjective*, *noun-noun-adjective*, etc. We then applied the TF-IDF [20] measure to keep only the pertinent terms. These steps aimed to affirm the concepts identified by experts on the top-down approach, enriching them with their synonyms and searching for new specific concepts. After reviewing the terms retained with the legal expert, we determined topics of interest (bankruptcy proceedings, settlement proceedings, reorganization proceedings, creditor claims, debtors' rights, and insolvency practitioners), thus enabling us to classify insolvency cases and associate a list of features with each topic. Below is the list of

features related to creditor claims of unpaid debts (refer to Table 2).

Following creating the ontology of cases and identifying features that affect each topic of interest, we collaborated with a legal expert to map relevant case features to appropriate concepts in the case ontology.

3.2 Case Indexing

Various methodologies exist for case indexing, including nearest-neighbor, inductive, and knowledge-guided approaches [21], [22]. Recent methodologies, such as neural networks (NNs), genetic algorithms (GAs), and gray correlation analyses, offer promising results in CBR systems [23]. Despite their individual advantages and drawbacks, the chosen approach depends on the retrieval system's unique requirements. In our instance, we opted for a hybrid approach that combines the TF-IDF method to identify the topic of interest for each case, followed by the k-nearest-neighbor (KNN) method to compare two legal cases by calculating the euclidean distance between their features. This comparison was performed twice: once with equal weights and once using weights estimated by experts.

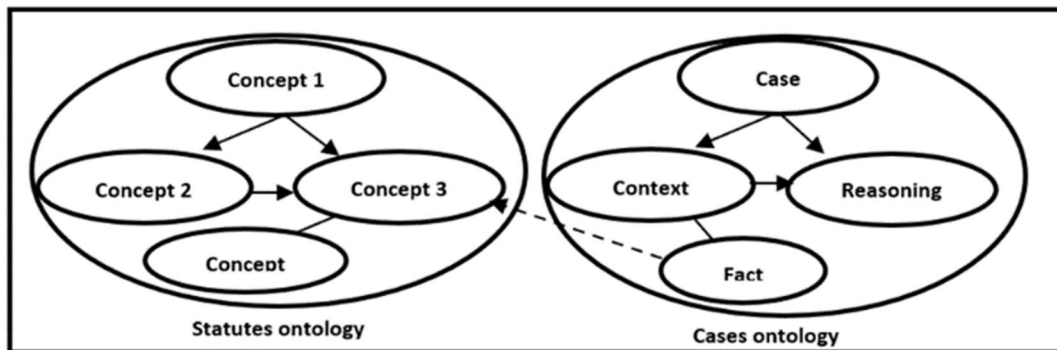


Figure 3: The Ontological Framework

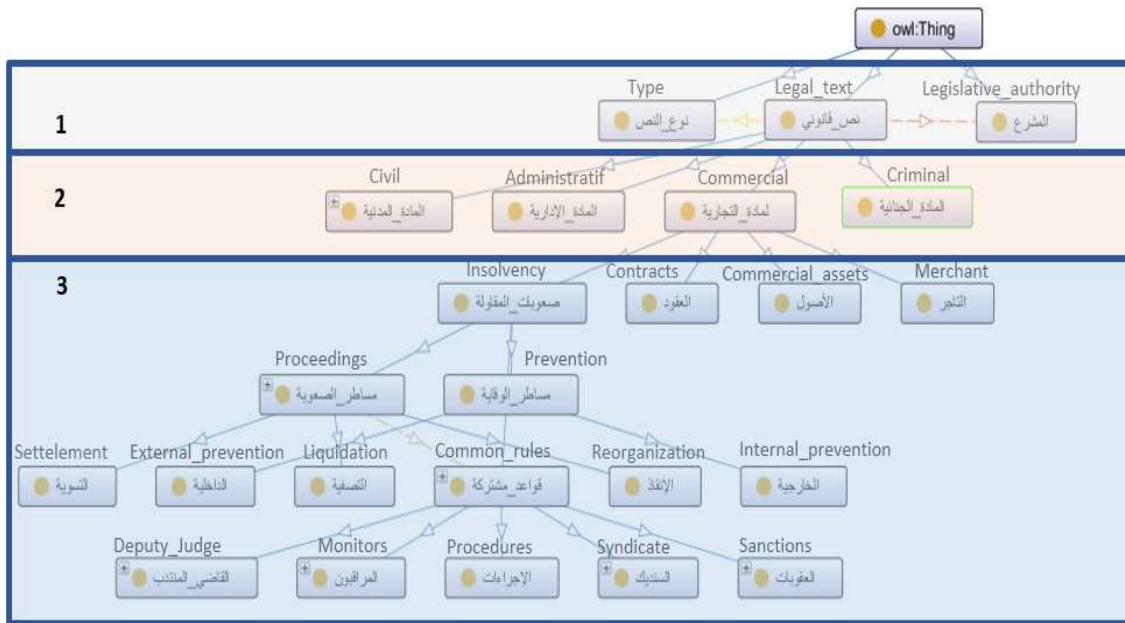


Figure 4: An Excerpt From The Ontology Of Statues. The Figure Shows The Structured Representation Of Legal Concepts And Their Interconnections

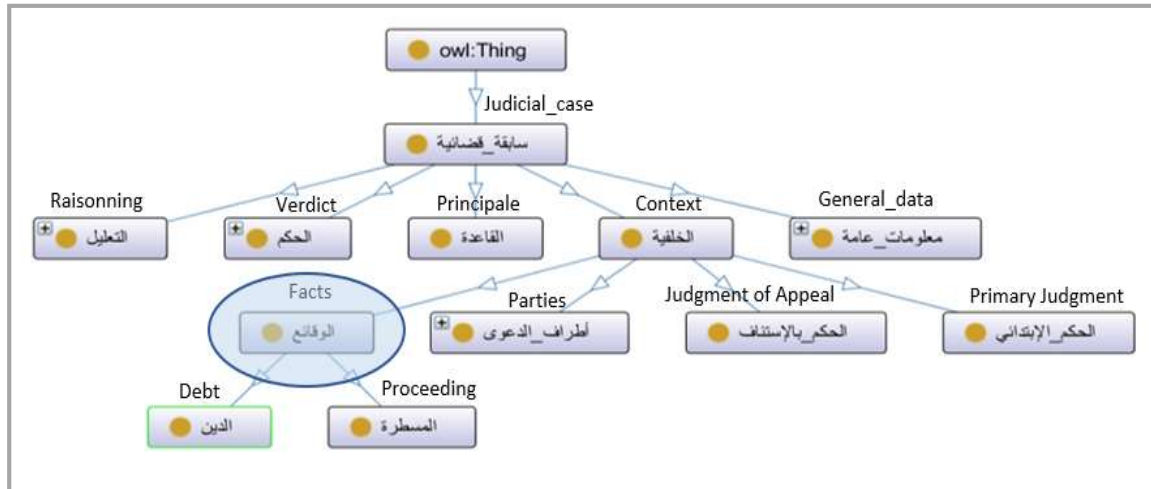


Figure 5: An Excerpt From The Moroccan Cassation Legal Case

Table 2: Case Properties Of Creditor Claims Of Unpaid Debts

Id. Feature	Feature	Id. Value	Value
1	Debtor_type (نوع المدين)	1	Individual (شخص ذاتي)
		2	A company (شركة)
2	Creditor_type (نوع الدائن)	3	Individual (شخص ذاتي)
		4	Employee (أجير)
		5	A company (شركة)
		6	Financial institutions (بنك)
3	Creditor_residence (مقر الدائن)	7	Inside (داخل التراب الوطني)
		8	Outside (خارج التراب الوطني)
4	Proceeding_name (اسم المسطرة)	9	No proceedings (بدون مسطرة)
		10	Liquidation (التصفية)
		11	Settlement (التسوية)

		12	Reorganization (الإنقاذ)
5	Debt amount (مبلغ الدين)	13	Actual monetary value of the debt
6	Debt age (تاريخ الدين)	14	Number of days
7	Debt Declaration Date (تاريخ التصريح بالدين)	15	Within the legal deadline (داخل الأجل القانوني)
		16	Outside the legal deadline (خارج الأجل القانوني)
8	Has_Priority (الإمتيار)	17	Regular debt (دين عادي)
		18	Outstanding debt (دين ممتاز)
9	Has_garanties (الضمانات)	19	Without guarantees (بدون ضمانات)
		20	With guarantees (بضمانات)
		21	Lease credit agreement (عقد انتمان إيجاري)
10	Has_support (سند)	22	With support (بدون سند)
		23	Without support (بسن)
11	Has_interest (بفائدة)	24	Interest-free (بدون فائدة)
		25	With interest (بفائدة)
12	Is_dispute_subject (موضوع نزاع)	26	Without dispute (بدون نزاع)
		27	Subject to dispute (موضوع نزاع)
13	Debt_currency (العملة)	28	National currency (بالعملة الوطنية)
		29	Foreign currency (بالعملة الأجنبية)

4. THE RETRIEVAL APPROACH

The core of our methodological approach is the realization of a hybrid solution that incorporates a novel weighting function into the standard Euclidean distance calculation, facilitating a more accurate and nuanced comparison of legal cases. The workflow of the proposed is represented by Algorithm 1.

<p>Algorithm 1: Legal Case Retrieval</p> <p>Input: Legal cases $C_i = \{T_i, F_{1i}, F_{2i}, \dots, F_{ni}\}$, Query $Q = \{T_q, F_{1q}, F_{2q}, \dots, F_{nq}\}$, Parameter α</p> <p>Output: Relevant cases $R = \{Cr_1, Cr_2, \dots, Cr_k\}$</p> <p>Step 1: Calculate $\mu F(i)$ and $\sigma F(i)$ for all i from the database of cases.</p> <p>Step 2: For each C_i do:</p> <p style="padding-left: 20px;">Step 2.1: For each F_{ij} in C_i do:</p> <p style="padding-left: 40px;">Step 2.1.1: Compute w_{ij} using Equation [Weight Function].</p> <p style="padding-left: 40px;">Step 2.1.2: Transform F_{ij} into F'^{ij} using Equation [Feature Transformation].</p> <p style="padding-left: 40px;">Step 2.1.3: Normalize F'^{ij} into F''^{ij} using Equation [Feature Normalization].</p> <p style="padding-left: 20px;">Step 2.2: End For</p> <p>Step 3: End For</p> <p>Step 4: For each F_{qj} in Q do:</p> <p style="padding-left: 20px;">Step 4.1: Transform F_{qj} into F'^{qj} using Equation [Feature Transformation].</p> <p style="padding-left: 20px;">Step 4.2: Normalize F'^{qj} into F''^{qj} using</p>

Equation [Feature Normalization].

Step 5: End For

Step 6: For each C_i do:

Step 6.1: Compute $DISQ, C_i$ using Equation [Dist].

Step 7: End For

Step 8: Rank cases by their distances to Q .

Step 9: Select top k cases as the relevant cases R .

Step 10: Return R .

Every legal case is represented as a feature vector containing the topic and a list of associated features. Mathematically, this can be represented as in Equation 1:

$$Case_c = \{T, F_1, F_2, \dots, F_n\} \quad (1)$$

where n is the total number of features, T represents the topic of the case, and F_i denotes the i^{th} feature of the case.

In order to address the subjective goal inherent to the legal domain, we propose the following weight function for the features Equation 2:

$$w_i = \alpha \cdot \exp\left(-\frac{(F_i - \mu F_i)^2}{2 \sigma_{F_i}^2}\right) + (1 - \alpha) \cdot \frac{F_i}{\sum_{j=1}^n F_j} \quad (2)$$

where w_i is the weight of the i^{th} feature, α is a tunable parameter, F_i is the i^{th} feature, μF_i and $\sigma_{F_i}^2$ are the mean and standard deviation of the i^{th}

feature across all cases, and n is the total number of features.

To further improve the case comparison, we transform the original feature space into a new space in which the features are uncorrelated by the following Equation 3:

$$F_i' = \sum_{j=1}^n v_{ij} \cdot F_j \quad (3)$$

where F_i' is the i^{th} transformed feature, and v_{ij} are the elements of the eigenvector matrix obtained from the covariance matrix of the features. Finally, we normalize the features to ensure they all fall within the same scale calculated by Equation 4:

$$F_i'' = \frac{F_i' - \min(F_i')}{\max(F_i') - \min(F_i')} \quad (4)$$

Where F_i'' is the i^{th} normalized feature, and F_i' is the i^{th} transformed feature. The Euclidean distance between two cases, A and B, is then computed using the weight function and the transformed and normalized features through equation 5:

$$DIS_{AB} = \sqrt{\sum_{i=1}^n w_i \cdot (F_{A,i}'' - F_{B,i}'')^2} \quad (5)$$

4.1 Database Design

The designed database encapsulates the inherent properties of each legal case, including topics of interest, the list of features, and the indexing template that associates case references with appropriate features. The relational schema of the database and its associated relationships are represented using a UML class diagram, shown in Figure 7. The schema is structured to ensure contextual relevance and includes management rules:

- A topic of interest encompasses one or more features.
- A feature possesses multiple possible values and has a default value and weight designated by legal experts.
- The principal components of a case include the principle, context, verdict, and reasoning.

- One or more features index each context, ensuring contextual relevance.

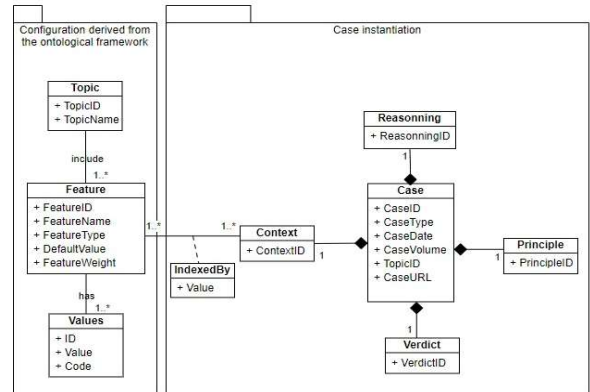


Figure 6: A Part Of The Diagram Class For Designing The Data Base

4.2 Query Processing

Querying the database necessitates converting the user's information into a query expression interpretable by the MLCRS using shared ontologies. Users construct queries utilizing the concepts and features in the case ontology, which are subsequently submitted to the search engine (refer to Figure 8). The relevance of legal cases to a user's query is determined by calculating the weighted Euclidean distance between the query and each case in the database. Cases that yield the smallest distances are thus deemed most relevant.



Figure 8: Initial Interface Prototype. The Text Is Translated Into English For Illustration

5. EVALUATION AND DISCUSSION

5.1 Experiment

In this section, we evaluate the precision of the Moroccan Legal Case Retrieval System (MLCRS) by analyzing its performance on a benchmark dataset containing 140 diverse cases. We employ three distinct data classification and retrieval methods to ensure a comprehensive assessment.

The dataset used was divided into specific categories:

- 40 cases related to settlement proceedings.
- 30 cases related to liquidation proceedings.
- 70 cases related to creditor claims.

The retrieval methods employed include:

- The Keyword-Based Search (KBS).
- The k-nearest-neighbors (k-NN).
- The weighted k-nearest-neighbors (weighted k-NN).

This experimental setup enables us to evaluate the system's precision in effectively retrieving data across various legal case topics.

5.2 Results

As expected, the KBS method had the lowest accuracy at 51.2% (see Table 3) due to keyword reliance. Its limitations can lead to missing information by relying on accurate user keyword choices, which affects overall accuracy. The k-nearest-neighbors (k-NN) method, a more intuitive and data-driven approach, showed better precision at 69.9% on average across all categories. It works well with diverse datasets but can struggle with inhomogeneous or imbalanced data. In our study, it did not outperform the weighted k-NN method due to dataset characteristics, emphasizing the need for a proper understanding of the dataset. The weighted k-NN method excelled with precision rates of over 80% for all categories, averaging 83.8%. It introduced relative topic weights, enhancing case differentiation and accuracy. Assigning weights was complex and required expertise, but it brought substantial benefits. Research into automated weight assignment methods could be explored.

5.3 Analysis

In juxtaposition with the work presented by [6], which proposed an ontological Chinese legal consultation system specific to the Chinese legal context, our method for the Moroccan legal

system exhibited marked improvements. The system designed by [6] demonstrated a retrieval accuracy of approximately 72%, particularly when considering semantic nuances within the Chinese language. However, our Moroccan Legal Case Retrieval System (MLCRS), especially when combined with the weighted k-NN method, surpasses this with an average precision of 83.8%. The differences in linguistic structures and semantics between Arabic and Chinese would have contributed to the varying efficiencies of the ontologies in each system. Despite these differences, the potential of the ontological framework in both studies is evident. Both research efforts underline the importance and adaptability of ontologies in legal domain applications, transcending linguistic and regional barriers.

Additionally, other related works in Table 1, although not strictly confined to the legal domain, have employed similar techniques for data retrieval. For instance, the study presented in [5] focusing on architectural design retrieval achieved an efficiency of around 74% in case-based retrievals. Similarly, the research by [8], which developed an ontology-based CBR approach for urban freight transport, reported an efficiency of roughly 77%. Compared to these results, our MLCRS, given its specificity to the Moroccan legal domain and Arabic language, has demonstrated superior performance, suggesting the effectiveness of our hybrid approach.

Table 3. Comparison of retrieval precision.

Topics/ Methods	Settlement proceeding (precision %)	Liquidation proceeding (precision %)	Creditor claims (precision %)	Total (%)
KBS	49,8	48,2	55,6	51,2
k-NN	65,2	64,8	79,7	69,9
weighted k-NN	82,2	80,8	88,6	83,8

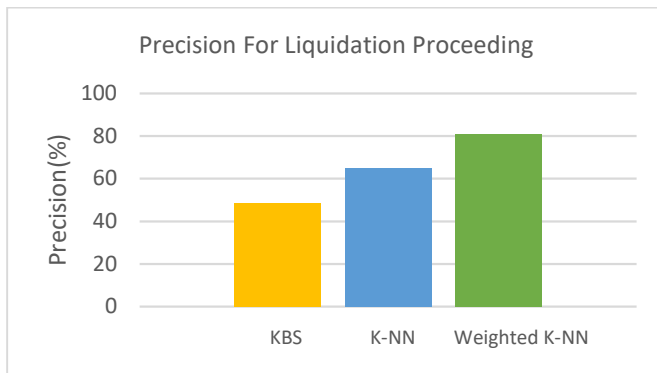


Figure 9: Precision For Liquidation Proceeding

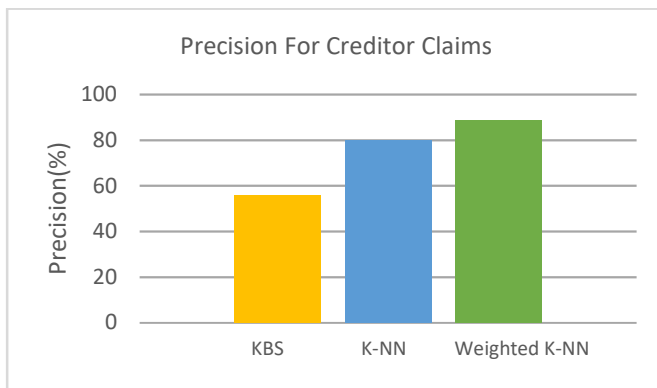


Figure 10: Precision For Creditor Claims



Figure 11: Precision For settlement Proceeding

6. CONCLUSION

Our study aimed to construct a legal case retrieval framework tailored for legal professionals, considering the specific characteristics of Moroccan law. We employed a hybrid approach that merges ontologies with case-based retrieval. The ontological framework

narrows the search scope to relevant topics of interest, indexing cases using topic-specific features and concepts. The case-based retrieval technique utilizes feature weights derived from experts' knowledge and computes similarity using the nearest-neighbor method. Our proposed approach demonstrates superior precision compared to traditional methods like classic KNN and keyword-based retrieval. Despite making significant strides in legal case retrieval, particularly within the Moroccan context, we have identified several key areas for future research:

Interoperability with other languages: As a potential avenue, we aim to ensure that our system remains efficient and compatible across various languages and legal systems. While our success in the Moroccan context is promising, expanding to languages with distinct linguistic structures, such as French or English, will present challenges.

Automated weight assignment in weighted k-NN: An existing limitation lies in the manual assignment of weights in the weighted k-NN method. To address this, future research should concentrate on developing techniques for automated weight assignment that can dynamically adapt based on changing legal precedents and legislative modifications.

Deep learning integration: The realm of deep learning has exhibited great potential in various domains, including legal informatics. Integrating deep learning methodologies into our current framework could further enhance the system's precision.

By addressing these gaps, future research endeavors have the potential to shape the next generation of legal retrieval systems, benefiting not only Morocco but also a broader international audience.

REFERENCES

- [1] A. C. Hutchinson and P. J. Monahan, "Stanford Law Review Law, Politics, and the Critical Legal Scholars: The Unfolding Drama of American Legal Thought", 1984. [Online]. Available: http://www.jstor.org/URL:http://www.jstor.org/stable/1228683http://www.jstor.org/stable/1228683?seq=1&cid=pdf-reference#references_tab_contents

- [2] S. Reilly *et al.*, 'Specific Language Impairment: A Convenient Label for Whom?', *International Journal of Language and Communication Disorders*, vol. 49, no. 4. Wiley-Blackwell Publishing Ltd, pp. 416–451, 2014. doi: 10.1111/1460-6984.12102.
- [3] I. Watson and F. Marir, 'Case-Based Reasoning: A Review'. [Online]. Available: <http://www.ai-cbr.org/classroom/cbr-review.html>
- [4] A. Zaanoun, 'MOROCCO: THE IMPACT OF THE DIGITIZATION OF PUBLIC SERVICES', 2023.
- [5] V. Ayzenshtadt, A. Mikyas, K.-D. Althoff, S. Bukhari, and A. Dengel, 'Ontology-based Communication Architecture Within a Distributed Case-Based Retrieval System for Architectural Designs'. [Online]. Available: <http://fipa.org>
- [6] N. Zhang, Y. F. Pu, S. Q. Yang, J. L. Zhou, and J. K. Gao, 'An Ontological Chinese Legal Consultation System', *IEEE Access*, vol. 5, pp. 18250–18261, Aug. 2017, doi: 10.1109/ACCESS.2017.2745208.
- [7] D. C. Corrales, A. Ledezma, and J. C. Corrales, 'A case-based reasoning system for recommendation of data cleaning algorithms in classification and regression tasks', *Applied Soft Computing Journal*, vol. 90, May 2020, doi:10.1016/j.asoc.2020.106180.
- [8] A. Bouhana, A. Zidi, A. Fekih, H. Chabchoub, and M. Abed, 'An ontology-based CBR approach for personalized itinerary search systems for sustainable urban freight transport', *Expert Syst Appl*, vol. 42, no. 7, pp. 3724–3741, May 2015, doi: 10.1016/j.eswa.2014.12.012
- [9] J. Andreasik, 'Knowledge management model based on the enterprise ontology for the KB DSS system of enterprise situation assessment in the SME sector', in *Advances in Intelligent Systems and Computing*, Springer Verlag, 2019, pp. 146–156. doi: 10.1007/978-3-319-94229-2_15.
- [10] J. Andreasik, 'Enterprise Ontology According to Roman Ingarden Formal Ontology', 2009, pp. 85–94. doi: 10.1007/978-3-642-00563-3_8.
- [11] A. Getman, V. Karasiuk, Y. Hetman, and O. Shynkarov, 'Ontological representation of legal information and an idea of crowdsourcing for its filling', in *Advances in Intelligent Systems and Computing*, Springer Verlag, 2019, pp. 179–188. doi: 10.1007/978-3-319-97885-7_18.
- [12] J. Bagby and T. Mullen, 'Legal ontology of sales law application to ecommerce', *Artif Intell Law (Dordr)*, vol. 15, no. 2, pp. 155–170, Jun. 2007, doi: 10.1007/s10506-007-9027-3.
- [13] K. Belhoucine, M. Mourchid, A. Mouloudi, and S. Mbarki, "A Middle-out Approach for Building a Legal domain ontology in Arabic," in 2020 6th IEEE
- [14] K. Belhoucine, M. Mourchid, S. Mbarki, and A. Mouloudi, "A Bottom-Up Approach for Moroccan Legal Ontology Learning from Arabic Texts," 2021, pp. 230-242.
- [15] N. J. Kings and J. Davies, 'Semantic Web for Knowledge Sharing'. [Online]. Available: <http://www.flickr.com/>
- [16] J. M. Juarez, J. Salort, J. Palma, and R. Marin, 'Case Representation Ontology for Case Retrieval Systems In Medical Domains'.
- [17] M. Silberztein. "NooJ Platform." <https://nooj.univ-fcomte.fr/> (accessed 20-05-2023).
- [18] M. Silberztein, *Formalizing Natural Languages: The NooJ Approach*. Wiley, 2016.
- [19] S. Mesfar, "An Automatic morpho-syntactic analyzer and a named entities recognition system for standard Arabic," Ph.D., Franche-Comté University, 2008.
- [20] R. Feldman *et al.*, "Text mining at the term level," in *Principles of Data Mining and Knowledge Discovery*, Berlin, Heidelberg, J. M. Żytkow and M. Quafafou, Eds., 1998// 1998: Springer Berlin Heidelberg, pp. 65-73.
- [21] D. Gardingen and I. Watson, 'A web based CBR system for heating ventilation and air conditioning systems sales support'. [Online]. Available: <http://www.ai-cbr.org>
- [22] K. S. Shin and I. Han, 'Case-based reasoning supported by genetic algorithms for corporate bond rating', *Expert Syst Appl*, vol. 16, no. 2, pp. 85–95, 1999, doi: 10.1016/S0957-4174(98)00063-3.
- [23] S. Slade, 'Case-Based Reasoning: A Research Paradigm', 1991.