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Enhancement of information retrieval systems on digital educational platforms

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During the pandemic, the use of remote work through IT tools has highlighted the importance of information retrieval. With the rising digitalization of the world, automation continues to expand. In the field of education, distance learning has become widespread, while hybrid training remains a viable alternative. Students rapidly adapted to distance learning and began using e-learning systems, despite their limited proficiency in navigating various features. One of the main challenges they faced was the inadequacy of the retrieved information. This study aims to propose a new approach to information retrieval within an e-learning system that adheres to the SCORM standard. Students will be able to search the teaching platform by entering query keywords. In cases where the requested resource is unavailable, the system extends the search to external sources on the Internet, using an advanced information retrieval method that has shown highly promising results.

Keywords: *e-learning; information retrieval system; digital educational platforms; ontology.*

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1. Introduction

The main objective of an information retrieval system is to provide the user with a response relevant to the user's request. Considering the user's destination domain and the IRS performance criteria, this response needs to be as specific as possible.

On the other hand, e-Learning systems are considered today as a very reliable source of data for distance learning. The world is currently moving towards these systems due to their advantages in terms of learning organization, cost and time reduction, training creation and dissemination, and also the possibility of using these systems as an alternative solution to face-to-face training in the case of major disruptions such as COVID 19, where these systems are the only possibility to ensure the continuity of training, especially for the higher level. The objective of this work is to propose a hybrid approach to information retrieval based on an information retrieval system and an e-Learning system, our proposal is in two steps: in a first step, the search for resources requested by the user is performed in the e-Learning system. Then, in case of failure, the search is done in external resources based on an ontology-based query enrichment approach [1]. In this case, the user is faced with two possibilities: either the e-Learning system responds perfectly to the user's request and therefore the system's objective is achieved, or this system does not have the right resource, or the user is not satisfied with the proposed resource and therefore we move on to step 2 where we have to look for external resources to satisfy the user (the learner). In the rest of this work, we start with state of the art in query enrichment approaches, then we present our approach, then we approach the evaluation of our system, and we end with a conclusion and perspectives.

2. Related studies

Several researchers have recently looked at web-based apps. Each online application has three main levels, according to F. P. Rokou et al. [2]: the program's web-based nature, the educational setting, and the individualized administration of learning resources. An information system that includes a web server, a network, a communication protocol like HTTP, and a browser is referred to collectively as a web-based program. Users' data contribute to changes in the system's status and behavior. The educational context describes the pedagogical model utilized along with the instructor's aims. The rules and procedures for selecting learning resources based on student characteristics, educational objectives, the teaching method, and the available materials are all included in the personalized administration of online learning materials. These three variables have been blended and integrated into e-learning systems through numerous efforts, leading to numerous standardization projects. Some efforts, such as the IEEE Learning Technology Systems design (LTSC), Instructional Management Systems (IMS), and Sharable Content Object Reference Model (SCORM), have concentrated on the common design and format of learning environments. The sharing and sequencing of learning items, also known as learning objects, between various e-learning systems are defined and provided by IMS and SCORM. Their primary goals are to standardize teaching and learning techniques and to model the management of interoperable educational data that is pertinent to the educational process. The content packaging concept and the sequencing paradigm were first introduced by IMS and SCORM, respectively. Content packaging, activity trees, learning activities, sequencing rules, and navigation models are the primary technologies behind these approaches. Their navigation models explain how learner- and system-initiated navigation events can be triggered and handled, while their sequencing models define a way to characterize the expected behavior of a learning experience. Additionally, Juan Quemada and Bernd Simon provided a framework for instructional strategies and resources [3]. According to their approach, educational activities consist of one or more instructors and take place in a virtual setting on a predetermined timetable. According to F. P. Rokou et al. [4], stereotypes are incorporated into instructional design for educational systems, and current UML (Unified Modeling Language) packet diagrams are appropriately modified. As a result, we think that adding an educational content framework based on learning resources to an e-learning system-one that contains ontology-based features and hierarchical semantic associations would enable the system to provide learners flexible and intelligent learning. The set of educational materials, the available learning sequence, and the structure of the educational concepts, such as the superior or inferior concepts linked with the learning contents, could all be visualized enabled by the hierarchical structure of the contents.

3. Proposed approach

Our proposed approach involves dividing this task into several distinct steps, beginning with the user's query (here called the learner's inquiry), which in this context refers to the learner's question, and concluding with the query expansion to enhance the retrieval process. The first and essential step in this methodology is the careful analysis and transformation of the question posed by the user. This initial stage lays the foundation for any information retrieval system, especially in natural language processing, where understanding the nuances of the learners request is crucial. The success of the subsequent retrieval process depends on the system's ability to correctly comprehend the user's query, which is ensured by the efficient processing of this step. We can improve the way information is found and retrieved by breaking the task into manageable stages, which will ultimately result in a more accurate and pertinent answer to the learner's question.

4. Pre-processing request

Given that the intended users of this technique are university-level students with a high degree of topic knowledge and an understanding of their information needs, this step is rather simple. In this context, query preprocessing is largely concerned with the deletion of non-essential terms, commonly

referred to as "stop words," using a specified list of stop words. These stop words commonly include common syntactic elements such as articles, conjunctions, and prepositions, which carry little semantic weight in the information retrieval process. This step also addresses words that may result from input problems, such as typographical errors, syntax issues, or other input-related anomalies. The major purpose of the preprocessing phase is to decrease query ambiguity and unneeded data. By deleting these unnecessary terms, the system ensures that only the most important terms, which are semantically significant and related to the user's goal, are retained. This phase is critical for removing any noise or ambiguity that may delay the retrieval process. The filtered terms are then used in the subsequent stages of information retrieval, while superfluous words are deleted to simplify the query for more efficient processing. After completing the preprocessing stage, the output is a refined list of important concepts retrieved from the original query. This list includes just the meaningful words, phrases, and other components that will be employed in the next step, query enrichment. This stage prepares the query for further enhancement and refinement, allowing for a more specific and focused search in the information retrieval system.

5. E-learning system resource search

The user's request is cleaned up and just the key terms are kept before moving on to the next stage, which is searching the E-Learning system for materials that fit the user's request. The learning management system (LMS) is structured as follows: All information regarding the resource's content is contained in the DATA file. The learning resource's material is arranged or structured in the Organization file. The learning resource's content is described in the item file. All of the useful activities associated with this resource are contained in the Activities file. The QUIZ file includes a number of practice exams to gauge the student's proficiency. The DATA file is browsed in this stage to see if the resource corresponds to the user's request.

6. Data source selection

The user is now given access to all of the platform's resources, giving them the chance to select the one that best meets their needs. The path found in the organization file is used to gain access to the resource, and its content is then shown. In this case, there are two conceivable outcomes.

Situation 1: When the suggested resource exactly fits the user's search, the process is complete. After finding the desired resource in this scenario, the user can stop here. He can then use the tool to accomplish their learning objectives. This situation will make it quick and simple for the user to use the resource he has chosen.

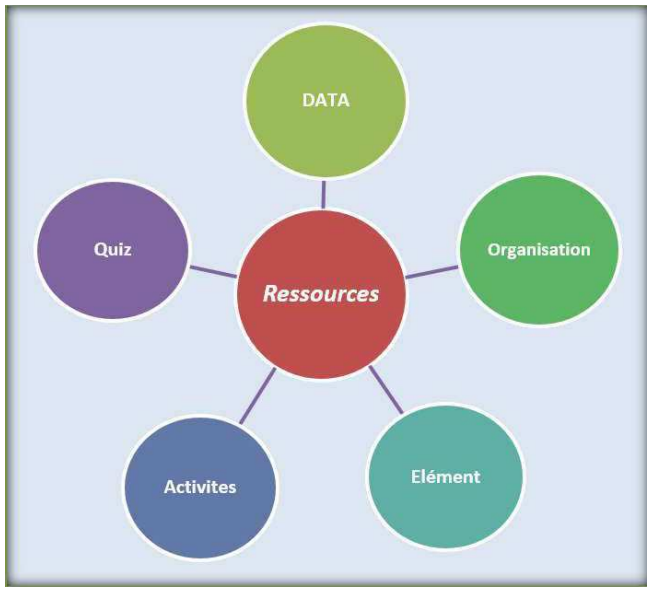

Fig. 1. LMS system organization.

Situation 2: When the suggested resource does not exactly match their search, we are compelled to locate an additional external resource to satisfy their need. At this point, we are using an ontology-based information retrieval approach and the list of terms that best describe the user's desire (D). This method involves communicating with the user while using a domain ontology to extract the entire domain from the query. The latter just needs to select the precise research area from a list provided by the system, and it will take care of identifying the appropriate resources.

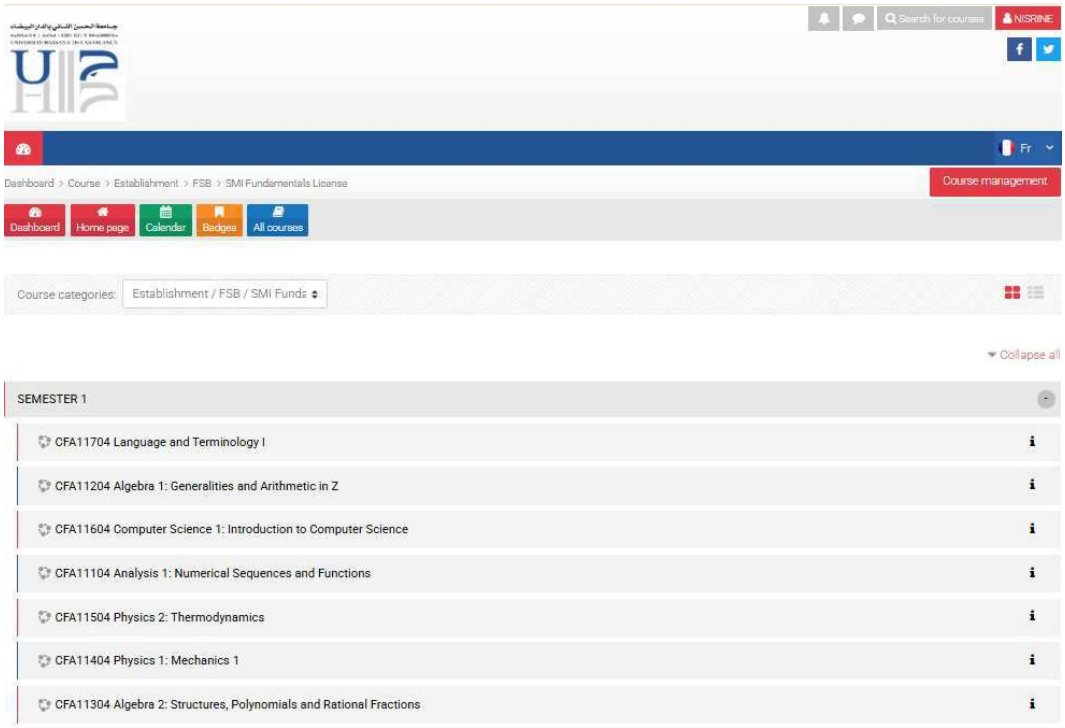

Fig. 2. Digital educational platform home interface.

Fig. 3. The interface of a document found on the Digital educational platform.

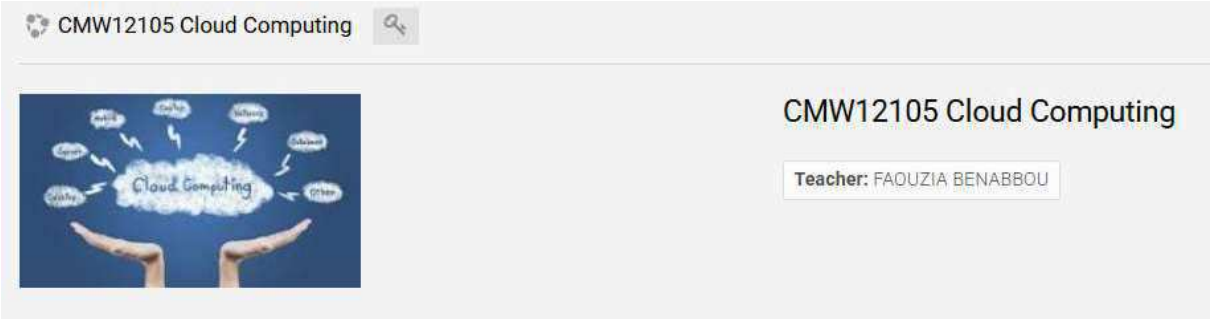

Fig. 4. The interface of a viewed course in the Digital educational platform.

7. Retrieval system

This approach relies on the use of a domain ontology to enrich the initial query by extracting relevant terms. The objective is to target the maximum number of documents belonging to a specific domain, in order to provide more precise and relevant results.

In this same approach, we encourage the interaction of the user with the system to refine the user's need and choose the domain that best corresponds to user's request. Depending on the user's choices, the query is then adapted to take these preferences into account, which makes it possible to further refine the search results.

The implementation of this approach in the e-learning system is specifically aimed at targeting education-related documents. By involving the user in the information retrieval system (IRS), we seek to guarantee greater precision by allowing him to choose the desired domain.

The objective of this step is to search the Internet for all the documents corresponding to the user's query using the new enriched query. This allows us to deliver relevant and educational domain-specific results, leveraging domain ontology-based enrichment to refine the search. By addressing the two situations, the user could request a resource through the e-learning system and conduct an external search on the Internet using the domain ontology, we account for the user's potential to conduct a combined search using our method.

Fig. 5. The interface of a viewed course in the Digital educational platform.

8. Evaluation

Establishing a rigorous experimental framework is critical for comprehensively evaluating the efficiency of a digital learning platform. This framework should include a fully working platform with an enhanced information retrieval system that is intended to solve and bridge any gaps in user requirements. The review method should not only assess the system's ability to recover relevant educational content, but also consider instances in which typical search techniques may fail, necessitating alternative retrieval approaches.

In the preliminary phase, we conducted a variety of manual trials on several online learning platforms, concentrating on specific search terms obtained from real student requests. These questions covered a wide range of academic areas and levels of complexity, from basic factual questions to advanced conceptual inquiries. The main objective of these studies was to determine the platform's ability to accurately and efficiently respond to these inquiries via an integrated search engine.

Furthermore, we investigated scenarios where the platform's built-in search capabilities were insufficient, necessitating the use of a different information retrieval approach. This alternate strategy aims to improve search results by combining structured information, semantic analysis, and contextual indexing approaches. Our approach is based on a systematic organization of educational resources. This architecture guarantees that searches are consistent with the logical categorization of documents

and follow the SCORM (Sharable Content Object Reference Model) standard. We discovered that maintaining a well-defined content hierarchy resulted in searches for resources already available on the platform with a very high relevance rate, considerably boosting the accuracy and efficiency of information retrieval.

In addition, when the desired resource was not easily accessible through the platform's standard search functions, the alternative information retrieval technique proved to be highly efficient. This approach improved search results by utilizing advanced ranking algorithms, natural language processing techniques, and adaptive filtering mechanisms. The findings in both examples were impressively relevant, emphasizing the need for combining complementary search strategies to improve information availability inside digital learning settings.

Our findings demonstrate the need of using a multifaceted information retrieval strategy to improve digital learning platforms. By combining structured resource organization with advanced search techniques, we can ensure that users obtain the most relevant and contextually appropriate instructional content, hence boosting the overall learning experience and platform engagement.

9. Conclusion and perspectives

In this study, we provide a unique information retrieval (IR) approach intended for incorporation into e-learning systems, with the primary goal of increasing the relevance of retrieved resources. Our system uses an ontology-based IR framework in conjunction with active collaboration with the end user to ensure that the results are closely aligned with the user's individual requirements and expectations. The suggested approach is divided into two phases: first, it searches for documents in the accessible resources that meet the SCORM (Sharable Content Object Reference Model) standard and directly address the user's inquiry. When the first search provides insufficient or poor results, the system applies a dynamic enrichment method, which has shown tremendous promise in improving the quality and breadth of the obtained data. The primary goal of our method is to meet the user's information demands with high relevance and precision, removing the need for them to seek additional resources. Our strategy, which combines the capabilities of ontology-based retrieval and user involvement, not only enhances the accuracy of the findings but also indicates a potential route for future study in educational technology and information retrieval.

Looking ahead, we are continually refining our methodology to create a more powerful IR system capable of delivering highly relevant documents in substantially less time. In addition, we are adding a recommendation system that proposes candidate documents for comparable queries, which will improve the system's utility and user experience. This dual functionality delivering precise results quickly while also recommending related content makes our system a valuable tool for both learners and educators in digital learning environments.

Finally, our findings highlight the need for combining modern IR approaches with user-centered design to overcome the difficulties of information overload in e-learning systems. The suggested approach not only increases resource retrieval efficiency and relevance, but it also paves the way for future research in personalized learning and intelligent recommendation systems. Future study will focus on improving the system's performance, broadening its applicability to a variety of educational environments, and assessing its impact on learning outcomes.

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Удосконалення систем пошуку інформації на цифрових освітніх платформах

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Під час епідемії використання віддаленої роботи за допомогою IT-інструментів підкреслило важливість пошуку інформації. Зі зростанням цифровізації світу автоматизація продовжує розширюватися. У сфері освіти дистанційне навчання стало нормою, тоді як гібридне навчання залишається життєздатною альтернативою. Студенти швидко адаптувалися до дистанційного навчання та почали використовувати системи електронного навчання, незважаючи на обмежені навички використання різних функцій. Однією з головних проблем, з якими вони зіткнулися, була неадекватність отриманої інформації. Це дослідження має на меті запропонувати новий підхід до пошуку інформації в системі електронного навчання, який відповідає стандарту SCORM. Студент зможе виконувати пошук на навчальній платформі, ввівши ключові слова запиту. У випадках, коли запитуваний ресурс недоступний, система розширює пошук на зовнішні джерела в Інтернеті, використовуючи передовий метод пошуку інформації, який продемонстрував дуже перспективні результати.

Ключові слова: *електронне навчання; інформаційно-пошукова система; цифрові освітні платформи; онтологія.*