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An Ontology-Based Framework for Collecting E-Learning Resources

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Abstract. The World Wide Web has an immense amount of e-learning resources for the various branches of science; these are available as textbooks, presentations, video tutorials, pictures, and audio lectures. There is no doubt that these resources would help students understand academic courses better, especially those courses that require training and practical activities, such as computer science courses. This would also help the instructor clarify his ideas in an interesting and innovative way. Searching for the available and suitable resources on the internet is difficult and time-consuming because we need the exact specification of keywords that characterize each topic in the course syllabus. Collecting such material manually from scratch for each course in a specific domain of knowledge is an expensive and time-consuming effort.
Ontology is the identification of terms used in a specific domain of knowledge, and the specification of relations between them. It specifies a shared vocabulary for specialists in a certain domain to exchange information. It is perhaps the key solution to the problems related to knowledge sharing and reuse due to the inclusion of definitions of basic concepts and their relationships that can be understood by machines.
In this paper, a system is proposed to enable instructors to collect e-learning multimedia resources from the internet and automatically link them with topics in the syllabus of the intended course using the ontology of the domain of knowledge related to that course.

Keywords: Automatic Retrieval; Instructional Design; Knowledge Management; Ontology-Based Annotation; E-Learning

Introduction

The process of creating a course is a tedious and arduous process. It includes tasks like planning a map of the concepts, preparing words, gathering the suitable equipment, and creating evaluation methods of the students' performance. Experienced instructors know how much work is required to build learning materials from scratch, as it requires a lot of time, effort and expertise (Casey, & McAlpine, 2002). To reduce the time and effort for constructing a course, it is suggested to use various elements from existing courses. The author can also consult internet documents to add to the content of their course. This

combined content can then be scanned by the author who can pick the best elements and improve the overall quality of the entire course.
Web 2.0 introduced a number of applications like Blogging, Social networking, and other Web applications that made every user of the Web become an author, having all of the tools and information to publish and share creations on the Web (Carlos, Guillermo, & Eduardo, 2012). The result is an immense amount of information and multimedia content. To overcome the process of sorting through the proliferation of information and to automate the process of accessing these resources, imposing semantic abstraction of information is necessary. The main barrier to automatic access to information is that all existing information is represented freely by different information providers and concepts in the same domain are often expressed using different methods. The consequence is that the semantics of information are not understood by search engines and knowledge cannot be shared between data sources (Gardarin, Kou, Zeitouni, Meng, & Wang, 2003).

Ontology is the identification of terms used in a specific domain of knowledge, and the specification of relations between them (Gruber, 1993). It specifies a shared, machine interpretable vocabulary for specialists, and co-workers in a certain domain to exchange information. Ontology is becoming of increasing importance to a large number of applications, such as knowledge-based systems, information exchange, the semantic web, and application integration. Standard ontologies have been created for a large number of domains, to support the communication and information exchange between co-workers and experts in these domains. SNOMED (Price, & Spackman, 2000) is an example of a large structured and standardized vocabulary in the domain of medicine. UMLS is a semantic network of Unified Medical Language System. UNSPSC is an ontology that provides common terminology for products and services.

A number of recent studies in the domain of e-learning development focused on the use of ontology in supporting adaptive learning and personalization of course content (Sedleniece, & Cakula, 2012). Personalization is the process of adjusting the learning knowledge to distinctive learners by investigating their information, abilities and learning inclination (Devedžiü, 2006). The idea is based on the fact that every student consumes training material based on his own unique learning style, needs and interests, and ontology can play an important role in structuring course content in a way that facilitates easy delivery of course content to different styles of learners.
In this paper, a proposed system to assist course developers to automatically collect course multimedia teaching materials out of the available related Web resources using ontology is presented.

Background

The World Wide Web has had a great effect on information exchange. Users of the Web can electronically publish their ideas and innovations. This has produced a massive amount of documents and resources, and this amount is rapidly growing. The exponential increase of information makes it difficult to find useful information on the Web (Gardarin et al., 2003).

Ontology is the candidate technology to describe the semantics of the underlying information, as it identifies the terms and sorts of things used in a specific domain of application. Ontology in computer science is a kind of way to portray ideas in a specific domain, and the relations between them (Uschold, & Gruninger, 1996).

Ontology

Ontology is commonly defined as "a formal, explicit specification of a shared conceptualization" (Gruber, 1993). Software application integration is one of the common usages of ontology; the developers of an enterprise create a common ontology to be used for integrating its software applications. Ontology is also used as a common interchange format to translate from/to different software applications with different formats. Another usage of ontology is "Ontology-Driven Software Engineering", where specification and development of software is based on a given domain's ontology.

Finally, an ontology-based search is used to facilitate searches that use ontology for indexing information repositories (Uschold, & Gruninger, 2004).

Resource Tagging

Tagging is the process of adding special annotations or marks that attach a piece of information to a resource or an object for future referral. There are many purposes for tagging objects; users usually tag objects for the purpose of future retrieval of the objects. Tags are also used for sharing ideas about objects with other users, attracting attention to specific resources, marking contributions with self-referential tags, or evaluating specific objects (Gupta, Yin, & Han, 2010).

Applications of Ontology in the Educational Domain

Many research efforts revealed the importance of ontology and Semantic Web (Berners-Lee, Hendler, & Lassila, 2001), as a supportive means for educational-technology systems (Mizoguchi, & Bourdeau, 2000), (Sampson, Lytras, Wagner, & Diaz, 2004), (Aroyo, Dicheva, & Cristea, 2002). Ontology has a promising role in the field of instructional design and the development of course content because it can represent knowledge about content, supports course authors in creating content and provides easy accessibility of course content by students. Hence, it is likely that ontology will be useful in the domain of education (Boyce, & Pahl, 2007).

Technological perspective defines the knowledge organization, knowledge inference, information, information visualization, information navigation, information querying, subject domain ontology, and instructional knowledge. Application perspective defines sub concepts in knowledge construction, knowledge externalization, knowledge communication, and architectural knowledge. (Monique, Faiçal, Cyrille, Richard, Dominique, & Céline, 2007) defines ontology in the e-learning domain, which includes problem-situation, problem solving, critical analysis, case study, debate, cyber quest, projects, and exercises. (Marian, Bogdan, & Marius, 2010) developed a Semantic Web that defines educational ontology and consists of user profile, person, contact, and activities ontologies. This was implemented using Protégé-OWL ontology editor.

(Kum, & Elizabeth, 2011) provides an archive of confidential knowledge in the education domain. The ICT ontology consists of concepts, such as the ontologies of ICT curriculum, ICT Job, ICT Skill and ICT Research. (Feng, & Youquan, 2010) uses ontologies in the construction of an educational resources library to allow access to qualification systems of 9 countries in Europe. (Chung, & Kim, 2012) focuses on developing e-learning support system based on ontology enabling learners to customize paths of learning as per their understanding of curriculum and subjects.

1) Web-Based Educational Systems (WBES)

WBES is a new protocol for communication of knowledge is proposed that would implement content awareness through ontology to foster communication between different areas through the ability to understand shared information. Through this new high layer built model of communication, understanding the content and network communication is optimized. (Dicheva, Aroyo 2004).

2) Ontologies for Education (O4E)

This consists of technological and application perspectives. Technological perspective defines the knowledge organization, knowledge inference, information, information visualization, information navigation, information querying, subject domain ontology, and instructional knowledge. Application perspective defines sub concepts in knowledge construction, knowledge externalization, knowledge communication, and architectural knowledge (Aroyo, & Dicheva, 2004).

3) Ontologies for the Use of digital learning Resources and semantic Annotations on Line (OURAL)

This research project defines ontology in the e-learning domain, which includes problem-situation, problem solving, critical analysis, case study, debate, cyber quest, projects, and exercises(Monique, Faiçal, Cyrille, Richard, Dominique, & Céline, 2007).

4) Ontologies for E-Learning Systems in Higher Education

This is a Semantic Web that defines educational ontology and consists of user profile, person, contact, and activities ontologies. This was implemented using Protégé-OWL ontology editor (Marian, Bogdan, & Marius, 2010).

5) Information and Communication Technologies (ICT) in Education Ontology

ICT provides a central repository of classified knowledge in the education domain. The ICT ontology consists of concepts, such as the ontologies of ICT curriculum, ICT Job, ICT Skill and ICT Research (Kum, & Elizabeth, 2011).

6) European Credit Vocational System

This system uses ontologies in the construction of an educational resources library to provide a common access to the information regarding the qualification systems of nine European countries (Feng, & Youquan, 2010).

7) Ontology-based e-learning

Research in the domain of ontology-based e-learning focuses on developing ontology-based e-learning support system which allows learners to build adaptive learning paths according to their understanding of curriculum, syllabuses, and subjects of courses (Chung, & Kim, 2012).

The impact of multimedia instructional design on learners

Multimedia has a fundamental educational advantage of providing sensory input that is visually integrated and linguistically rich, enhancing the users' learning experiences (Mayer, 1997). A study prepared according to focused or split attention types was conducted on the effect of multimedia instructional designs on recall performances of learners with high , medium or low memory spans. The study revealed that a higher recall was shown in the focused attention type, while there were discrepancies and deviations between performance results of learners with different multimedia (Altun, 2012).

Architecture of the Proposed System

The main goal of the proposed system is to assist the instructor or the course designer to find related multimedia learning material on the Web and attach them automatically to each of the topics that comprise the syllabus of the course. This part will introduce the architecture of the proposed system and the details of each of its parts. The input to the proposed system is the syllabus provided by the instructor, which specifies the contents and topics included in the course. The output is an index of the syllabus topics with links to multimedia resources related to each topic with the facility to browse the course contents with the attached multimedia resources.

As it appears in Figure 1, the proposed system consists of four main components: key concepts extractor, Web resources collector, ontology extender, and subject Web-resources browser.

A. Key Concepts Extractor

The main function of this component is to analyze the topics of the provided syllabus to determine the key concepts that characterize each topic. The concepts are drawn from the domain ontology provided by the instructor and related to the domain of knowledge of the course. The output of this component is an index of the topics that constitute the syllabus of the course, tagged with the relevant domain concepts related to each topic. The known techniques of generalization and specialization are used to explore the taxonomy of the domain ontology concepts to specify the related domain concepts to each topic.

B. Web Resources Collector

The Web resources collector searches the Web for the multimedia resources related to each topic using the key concept tags that characterize these topics. The keywords used are extracted from the topics domain concepts index generated in the previous stage. The output of this component is a repository of links to Web resources related to each topic.

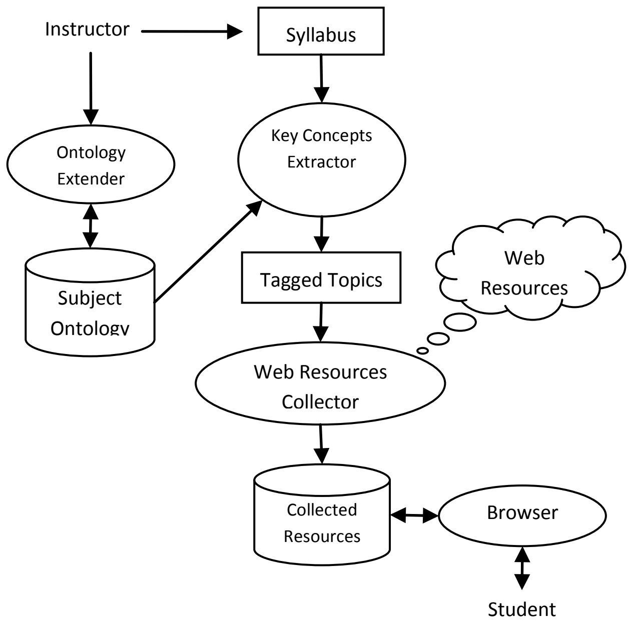

Figure 1: Architecture of the proposed system

C. Ontology Extender

The instructor uses this component to build the hierarchy of the subject ontology. This tool allows the instructor to input the main concepts and their associations related to the subject, which arranges the concepts in a hierarchical structure with the general concepts at the top levels of the hierarchy, and sub-concepts are branching from them at the lower levels of the hierarchy.

D. Subject Web-resources browser

The target of the proposed system is to provide the facility of browsing Web resources related to each syllabus topic on a selected subject. This component provides this facility. Through this component, the user/student will be able to go through the collected Web resources for a selected topic.

Implementation Of The Proposed System

This part describes the implementation aspects of the proposed system. The main modules to be discussed are the Key Concepts Extractor Module, and the Web Resources Collector module.

A. Key Concepts Extractor

The input to the key concepts extractor module is the syllabus of the intended course. Usually the syllabus include information about the course including objectives, outcomes, time table, and the most important part which is the course plan that lists the topics to be taught throughout the course. Figure 2 displays a sample database course syllabus.

```
<?xml version="1.0"?>
- <Syllabus>
  + <Chapter>
  - <Chapter>
      <Title>DATA MODEL</Title>
      <Topic>Business Rules</Topic>
      <Topic>Evolution of Data Model</Topic>
      <Topic>Hierarchy model</Topic>
      <Topic>Network model</Topic>
      <Topic>Relational model</Topic>
    </Chapter>
  - <Chapter>
      <Title>ENTITY RELATIONSHIP (ER) MODEL</Title>
      <Topic>Entity, Attributes, Relationship</Topic>
      <Topic>Types of attributes, null values and keys</Topic>
      <Topic>Connectivity, Cardinality</Topic>
      <Topic>Relationship Strength</Topic>
    </Chapter>
  + <Chapter>
</Syllabus>
```


Figure 2: Sample Database Course Syllabus

Key Concepts Extractor module traverses the domain concepts taxonomy related to the subject of the course, and searches for each concept in the list of topics of the input course. Figure 3, is an excerpt of the used ontology concepts hierarchy, where concepts are represented by ovals and relations are represented by arcs. Synonym relation indicates that two concepts have the same meaning and can be used interchangeably. For example, “ER Model” is a synonym concept to “Entity Relationship Model” concept.

Child relation indicates that a concept is more general than its child. For example, “Entity” concept is a more general concept of “Weak Entity” concept.

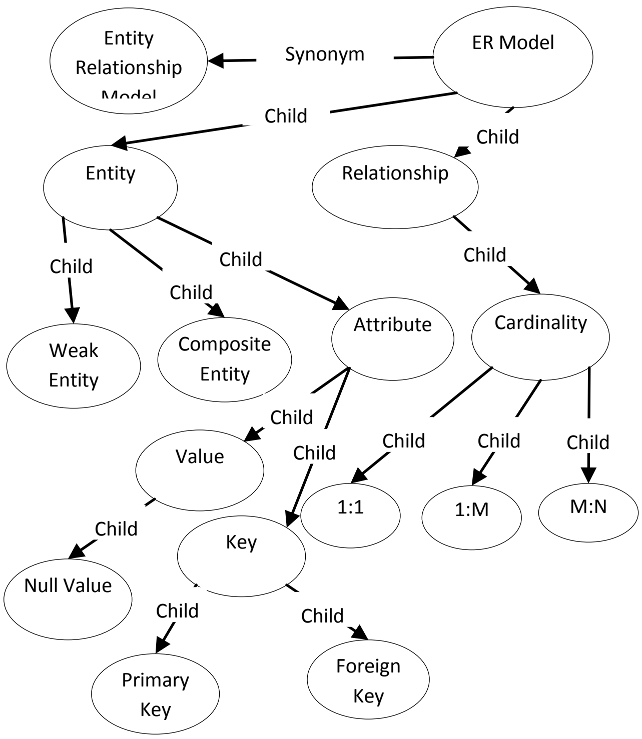

Figure 3: Sample of the concepts hierarchy of the database domain

Figure 4, is a pseudo code that describes the process of tagging syllabus topics with domain concept tags. It starts with reading the syllabus and ontology xml files, then for each concept in the ontology concepts list, it searches for this concept in each topic in the syllabus, if a concept is found in a topic, a tag record is appended to the TopicTags XML file. Figure 5. Displays a sample of the output TopicTags.XML file.

```
Input:  S: Syllabus XML file
        O: Ontology XML file
Output: TopicTags.XML
Steps:
        Read S
        Read O
        Get LC //List of all concepts  in O
        Get LT // List of all topics in S
        for each concept C in LC {
          for each T in LT {
            if ( C in T )
```

Figure 4: Key Concepts Extractor Pseudo Code

```
<?xml version="1.0"?>
- <TopicTags>
  - <Topic>
      <Title>Entity, Attributes, Relationship</Title>
      <Tag>Entity</Tag>
      <Tag>Attribute</Tag>
      <Tag>Relationship</Tag>
    </Topic>
  - <Topic>
      <Title>Types of attributes, null values and keys</Title>
      <Tag>Attribute</Tag>
      <Tag>Value</Tag>
      <Tag>Null Value</Tag>
      <Tag>Key</Tag>
    </Topic>
  - <Topic>
      <Title>Connectivity, Cardinality</Title>
      <Tag>Cardinality</Tag>
    </Topic>
  - <Topic>
      <Title>Relationship Strength</Title>
      <Tag>Relationship</Tag>
    </Topic>
</TopicTags>
```

Fig 5: Sample Output of the Key Concepts Extractor Module

B. Web Resources Collector module

The web resources collector module searches for tags in TopicTags.XML file and generates a search key for each tag, the search key is the full path of concept tag as indicated in the domain concepts hierarchy. For example, if the tag is

"Attribute" then the search key will be "ER Model Entity Attribute". The output of the web resources collector module is the list of multimedia resources attached to each topic after removing redundant occurrences of the search results. Figure 6 is a pseudo code of the web resources collector module.

```
Input:  TT: TopicTags.XML
        O: Ontology XML file
Output: TopicLinks.HTML
Steps:
            Read TT
            Read O
            for each T in LTopics {
                 Get LTG //List of tags of T
                 for each TG in LTG{

                    Get P = Path (TG) // Full path of the tag concept

                    Get SK = SearchKey(P)

                    Get SR = WebSearch(SK) // Search Result
```

Fig 6: Web Resources Collector Pseudo Code

Sample Run

This section demonstrates a sample run of the implemented prototype of the proposed system. The input to the course annotator module is the syllabus of the intended course as an XML file. Figure 7 shows the form that the instructor uses for selecting the syllabus file.

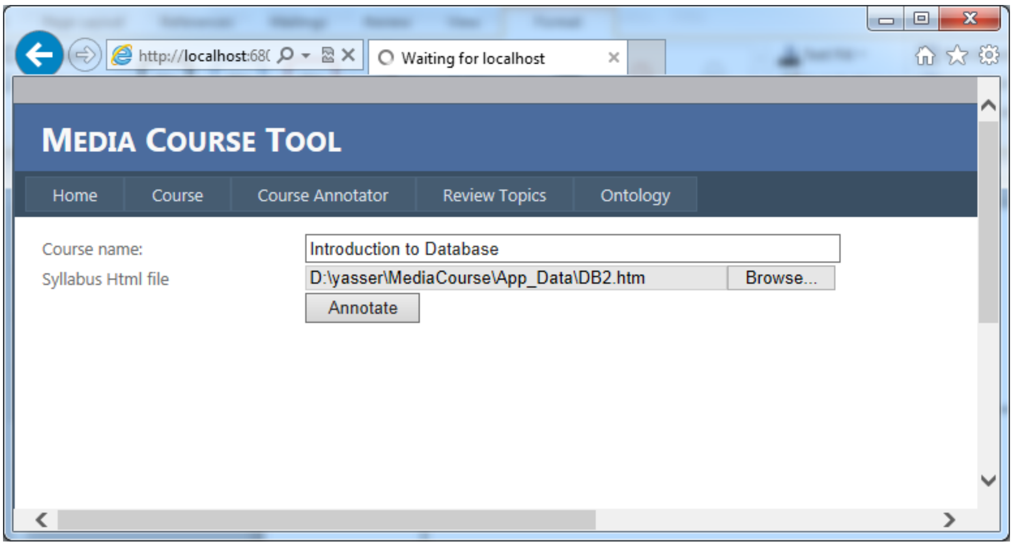

Fig 7: Course Syllabus selection form

The output of the proposed tool is a list of the topics found in the input syllabus file associated with links to the multimedia resources found on the Web and related to each topic as shown in Figure 8.

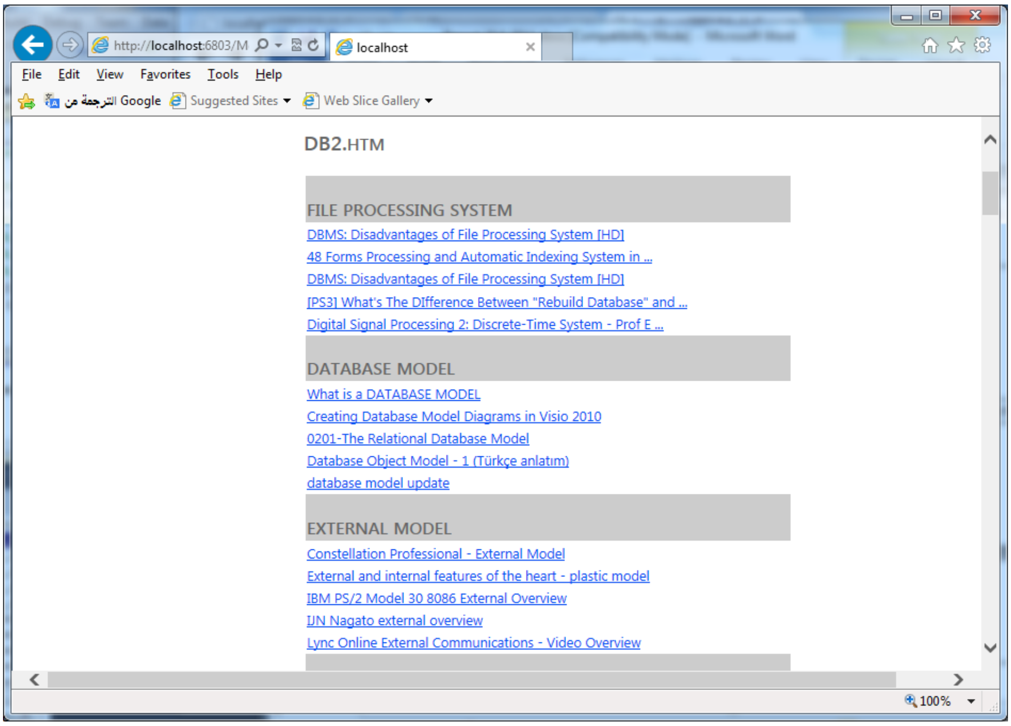

Fig 8: Syllabus topics with associated Web multimedia resources

Upon selecting one of the displayed links, the multimedia content of the selected link is displayed, as shown in Figure 9.

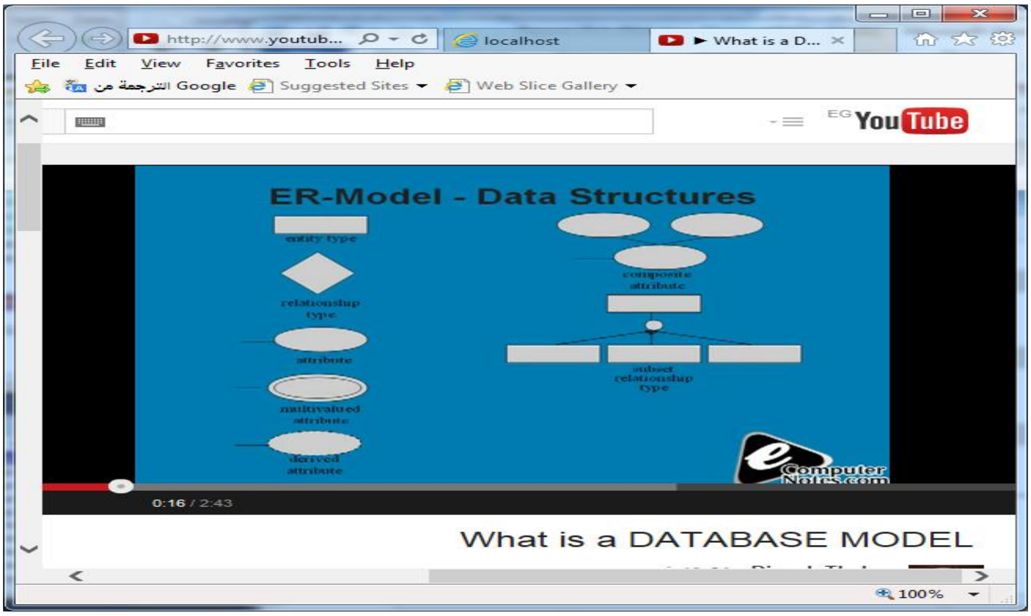

Fig 9: Displaying selected multimedia content

Results and Discussions

This section discusses the feasibility of using ontology for searching for web multimedia resources related to the topics of the selected syllabus.

Text-based search means using the topic description text directly as a search key to look for the matching multimedia resources, which is the currently used method for searching the web, while ontology-based search means using the domain ontology in formulating the search key.

The approach used for testing the feasibility of using ontology to formulate search keys instead of direct text-based search is to compare the number of correct/incorrect results for both types of search for the first 20 search results as shown in Figure 10.

Topic	**Text-based Search**		**Ontology-based Search**	
	Correct	Incorrect	Correct	Incorrect
Entity, Attributes, Relationship	20	0	20	0
Types of attributes, null values and keys	16	4	20	0
Connectivity, Cardinality	1	19	20	0
Relationship Strength	0	20	20	0
Weak Entities and Composite Entity	18	2	20	0

Figure 10: Feasibility Test

The results reveal that text-based search often get incorrect results, as it depends only on the terms found in the topic text, without having background knowledge about the context of the topic. For example, as it appears in Figure 10, the search for the topic "Relationship Strength" resulted in 0% correct results, as all the results were related to human relationships, instead of entity relationship model.

On the other hand, ontology-based search results were consistently correct, because it augments the context of the topic in the search key using the hierarchy of relevant domain concepts.

Discussion of Confronted Problems

During the development of the prototype of the proposed system, a number of problems were revealed. This section discusses these problems along with the suggested solutions.

A. Misleading description of multimedia resources

YouTube was selected as the source of video feeds using Google API to narrow the scope of the multimedia resources. The title and description of the feeds were selected for the matching course topics using the ontology terms. However, the initial results revealed that some of the video feeds had a description that did not match the content of the feed.

The proposed solution to this problem is to use matching at different levels of the ontology hierarchy and apply this matching to the more specific terms down the hierarchy of ontology terms. The second solution is to restrict the search for feeds to the authentic sites in YouTube, that is, those related to the domain of the course subject feeds.

B. Replication of the same content with different descriptions

The feeds are sometimes repeated in different sites with different descriptions. This problem causes lengthy matching resources results and can be filtered using other parameters of the feed, such as type or length.

Conclusion

Ontology is becoming of great importance in the field of education technology; it is the key for instructional design, integrating applications, information sharing and e-learning content design. This paper introduced an approach for associating academic course syllabi with available multimedia resources to topics on the Web. The proposed system has been designed and implemented to read the syllabus provided by the instructor, mark its topics with the domain concepts drawn from the domain ontology, use these concepts to search for multimedia resources on the Web, and attach them to each topic of the syllabus.

The most important result is the sharing and reusing domain ontology; it can be used for annotating many courses in the same domain Additionally, the system expedites the process of building the course content through the collection of the multimedia content of the intended course from the Web automatically, which reduces the burden of searching and collecting resources individually for each topic. The proposed system helps the course developer to provide multiple paths for course material that is suitable for different learning styles, which supports personalization of the designed course.

For students, the proposed system allows browsing the multimedia resources of the course indexed with the topics easily, and allows the selection of different multimedia resources, suitable for different styles of learning. The proposed tool also provides some amendment services, which allow the instructor to edit the ontology used for a specific domain and the resources allocated to each topic of the syllabus.

A prototype of the proposed Multimedia-Enabled Syllabus Browser has been implemented, and a sample run has been introduced that clarifies the idea of the proposed system. Also, the feasibility of the proposed system has been tested, and the results revealed that search results using ontology were consistently giving correct results compared with direct text-based search. Future research will continue to provide alternative solutions to the problems confronted.

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