An Approach to Multimedia Content Management

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Abstract: Standardized formalizations of the knowledge are used by domain experts to share information in the form of reusable knowledge. The primary objective of our work is the definition of an approach for multimedia content management. We reached that goal through a validation activity which lasted for the last three years, and was carried on through the application on different case studies, some of them described in detail in previously published papers. This approach aims to represent the knowledge through a mixed-iterative approach, where top-down and bottom-up analyses are applied on the knowledge domain we want to represent. We focused our research on some issues concerning Knowledge Management, strictly related to the process of making multimedia content-related knowledge easily available to users. We need to represent and manage this knowledge, in order to formalize and codify all the knowledge in the domain. This formalization can eventually lead us to easily manage that knowledge through the use of repositories.

1 INTRODUCTION AND RELATED WORK

In recent years the development of models to formalize the knowledge has been studied and analyzed. The ontologies - explicit formal specifications of the terms in a specific domain and relations among them (Gruber, 1993) (Guarino and Giaretta, 1995) (Jewell et al., 2005) (Hepp, 2007) (Gruber, 2008) - take an important part in these formalization approaches.

Ontologies have become common on the World Wide Web at the end of 2000. In the Web range there are many directory services of Web sites. These directory services are large taxonomies, which organize Web sites in categories. Other systems categorize products for e-commerce purpose, as in the case of Amazon. They use an implicit taxonomy to organize the products for sale by type and features. The World Wide Web Consortium (W3C) has developed the Resource Description Framework (RDF) (Brickley and Guha, 1999) (Lassila and Swick, 1999), a language for encoding knowledge on Web pages to make it understandable to electronic agents searching for information, as main foreground concept of the Semantic Web (Maedche and Staab, 2001) (Gómez-Pérez and Corcho, 2002) (Jacob, 2003) (Horrocks, 2008) (Simperi, 2009). The Defense Advanced Research Projects Agency (DARPA), in cooperation with the W3C, has developed DARPA Agent Markup Language (DAML) by extending RDF with more expressive constructs aimed at facilitating agent interaction on the Web (Hendler and McGuinness, 2000).

Many disciplines develop standardized formalization of the knowledge which domain experts can use to share information in the form of reusable knowledge. Many people use ontology (Noy and McGuinness, 2001) to define a common vocabulary for researchers who need to share information in a domain. It includes machine-interpretable definitions of basic concepts in the domain and relations among them.

Why would someone want to develop an ontology? Some of the reasons are:

- to share common understanding of the structure of information among people or software agents;
- to enable reuse of domain knowledge;
- to make domain assumptions explicit;
- to separate domain knowledge from the operational knowledge;
- to analyze the knowledge domain.

Sharing common understanding of the structure of information among people or software agents is one of the most common goals in the ontology development (Musen, 1992). For example, suppose

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that several different Web sites contain medical information, or provide medical e-commerce services. If these Web sites share and publish the same underlying ontology of the terms they all use, then computer agents can extract and aggregate information from these different sites. The agents can use this aggregated information to answer user queries or as input data to other applications.

Enabling reuse of domain knowledge was one of the driving forces behind our studies. Analyzing domain knowledge is possible once a formal specification of the terms and their structure is available.

In this work, we propose a process to identify and locate knowledge and knowledge sources within the domain, paying attention to multimedia objects. Valuable knowledge is then translated into explicit form through formalization and codification of the knowledge, in order to maximise its availability.

We want to represent knowledge through a mixed-iterative approach, where top-down (TD) and bottom-up (BU) analyses of the knowledge domain which has to be represented are applied: these are typical approaches for this kind of problems. In this case, they are applied following an iterative approach which allows, through further refinements, for a more efficient formalization, able to represent all the knowledge in the domain of interest.

We start from the concept of the "domain knowledge base". The fundamental body of knowledge available on a domain is the knowledge valuable for the users. We need to represent and manage this knowledge, to define a formalization and codification of the knowledge in that domain. After this formalization we can manage it using repositories.

In this paper, we summarize four different knowledge formalizations for multimedia contents, using our proposed approach (these case studies have been described in some scientific publications):

1) User Generated Contents from famous platforms (Flickr, YouTube, etc.);

2) audio recordings regarding linguistic corpus, and information added to that corpus with annotations;

3) knowledge associated with construction processes;

4) descriptions and reviews of Italian wines.

The paper is structured as follows: in Section Two we propose our approach to multimedia objects management, based on TD and BU analysis. In Section Three we present some remarks from case studies, carried on during the last three years, in which our approach was successfully applied, and Section Four includes an interesting example of industrial exploitation of our research. Lastly, in Section Five, the conclusion and some reasonings about our work are presented.

2 THE PROPOSED APPROACH

The basic concepts of our approach are the following:

1) there is no "correct" way or methodology for developing ontologies (Noy and McGuinness, 2001) and in general for analyzing and codifying/formalizing knowledge;

2) the main goal is to make the knowledge of a specific domain available and reusable for a specific purpose;

3) the formalized knowledge is not all the knowledge in the domain, but only the interesting information for the specific problem;

4) not-formalized information have to be inventoried (they can be included in the multimedia objects);

5) the formalized information will be represented using metadata;

6) the structure of the knowledge of the specific domain has to be analyzed using a TD approach;

7) the information in the object of the specific domain have to be analyzed using a BU approach;

8) the analysis process will be iterative, mixing TD and BU approaches.

2.1 Top-down Phase

When our knowledge or our expectations are influenced by perception, we refer to schema-driven or TD elaboration. A schema is a model formerly created by our experience. More general or abstract contents are indicated as higher level, while concrete details are indicated as lower level.

A TD elaboration happens whenever a higher level concept influences the interpretation of lower level information. Generally, the TD process is an information process based on former knowledge or acquired mental schemes; it allows us to make inferences: to "perceive" or "know" more than what can be found in data. TD methodology starts, therefore, by identifying a target to reach, and then pinpoints the strategy to use in order to reach the established goal.

We begin by formalizing the reference knowledge (ontology, taxonomy, metadata schema) to start classifying the information on the reference domain. The reference model could be, for instance, a formalization of one or more classifications of the same domain, formerly made in a logic of metadata.

2.2 Bottom-up Phase

In this phase, the knowledge to be represented is analysed by pinpointing, among the present information, the entities which are to be represented together with a reference terminology for data description.

We analyse the object that we consider as interesting in the domain, an object which contains the information of the domain itself; both information whose structure needed to be extrapolated and the information in them were pinpointed.

At this stage, the creation of the KB could be a complex task, because each object can have a different structure and a different way of presenting the same information. Therefore, it will be necessary to pinpoint the information of interest, defining and outlining it.

2.3 Iteration Phase

In this phase we try to reconcile the two representations of the knowledge in the domain that we obtained in the previous phases.

Thus, we want to pinpoint, for each single metadata found in the TD phase, where the information can be found in the metadata representing the knowledge of each object (which, for us, represents the knowledge we want to formalize, considering the semantic concept and not the way to represent it, absolutely subjective for every knowledge object).

Starting from this KB, further iterative refining can be made by re-analysing the information through different phases:

1) with a TD approach, checking if the information which are not represented by the chosen formalization can be formalized;

2) with a BU approach, analysing if some information about the actual items we want to describe, as we could find it as final users - e. g. on specialized Web sites - could be connected to formalized items;

3) with the iterations of phases, by which these concepts are reconciled.

This is obviously made only for the information that has to be represented. We want to formalize all the knowledge considered of interest by the users: only the most important information has to be chosen.

At the end of the analysis we are capable to define a formalization, in form of ontologies, taxonomies, metadata schema, capable of representing the knowledge of interest for the domain.

The final result of these phases will be a formalized knowledge which could be reused and .managed through Knowledge Management Systems (KMS), where the knowledge of interest is available (Pani, 2013).

3 SOME REMARKS FROM CASE STUDIES

We focused our research on some issues concerning Knowledge Management, strictly related to the process of making multimedia content-related knowledge easily available to people.

During the last three years, the proposed approach has been applied to four case studies, all related to industrial research (Lunesu, Pani and Concas, 2011) (Pani et al., 2012) (Argiolas et al., 2013) (Pani et al., 2013). The results we reached in all four cases strengthen our proposal.

We proposed an approach to solve the issue of the knowledge management related to User-Generated Content (UGC) (Lunesu, Pani and

Table 1: Comparison of the four case studies.

Case study	KB	Adopted solution
User-Generated Content	Multimedia Content generated by users	Ontology
Analytic Sound Archive of Sardinia	Linguistic information in audio content	Application profile
Construction processes	Building projects and associated objects.	Application profile
Italian wines reviews	Contents on Italian wines available on the Web	Taxonomy

3.1 User-Generated Content

We proposed an approach to solve the issue of the knowledge management related to User-Generated Content (UGC) (Lunesu, Pani and Concas, 2011). This approach is well suited for all those instances in which a multimedia content is involved, essentially because, in that case, associated information cannot be described through the use of the most known metadata standards. Special attention has to be paid to widespread standards such as Adobe's Extensible Metadata Platform (XMP), Dublin Core (DC) (Becker et al., 1997) (Hillmann, 2005), the Exchangeable image file format (Exif), and the International Press Telecommunication Council standard (IPTC).

The main goal was to study, design and create an ontology that could formalize the multimedia content semantics and geocoded data, starting from the already mentioned standards, in order to effectively represent the domain of interest. In fact, in those cases, a synergistic integration of an ontology based on the standards, with the use of a clearly defined mapping technique, allows for representing a great number of contents and metadata, as proven in the mapping example.

This mapping technique was especially useful to sort out so vast and complex knowledge field such as multimedia content. Dealing with mapping led to the necessity of using shared standards, rather than proprietary ones, now very widespread. The proposed approach may be used to support a software platform that allows for different actors to develop added-value services. Such services could be based on multimedia content insertion into a semantic organization context. It is clear that such an approach should rely on a powerful tool which could map all the information concerning the contents described in the ontology with the form used to represent it in a specific standard. The purpose was to offer a structure enhanced with semantics, which could serve as a base support for the creation of a Web content management software platform.

The platform, thanks to the modelled concepts, could give users the chance to collect and add contents that originated from varied sources (Web sites, Web portals, local files) and to influence the value of the contents though ratings, comments and preferences. Thus contents could be gathered, aggregated and geocoded, and then distributed to each user. Such a platform should clearly be provided with a powerful tool capable to “conform“ every piece of information about the added contents to the form designated as a representation standard within itself. In other words, it must be able to map any kind of metadata describing the contents.

Once again the ontology we created would be an impressive tool capable to fulfill that requirement.

The system could be accessible through mobile devices such as Personal Navigator Assistants (PNA), that would use a geolocalization system to know their location.

3.2 Linguistic Information in Audio Content

In this case, the knowledge was represented by a set of audio recordings in a corpus and linguistic information added to that corpus with annotations (Pani et al., 2012). We organized the information in the corpus formalizing those annotations through metadata schemas using the informal annotations made by the domain experts. We used this approach to associate the annotations to their texts, using the selected linguistic level. The proposed approach was experimented and validated during a project that aimed to create the Analytic Sound Archive of Sardinia (ASAS). The ASAS is a joint project by linguists and musicologists at University of Cagliari that had the purpose to create an institutional archive with a linguistically and musically annotated electronic corpus. This archive has an electronic corpus of spoken texts, linguistically annotated at various levels.

To build the ASAS, DSpace was chosen, since it fulfills all the requirements set by linguists and musicologists. As we expected, this tool turned out to be very efficient, easy to use, customizable and flexible, so easily allowing for the management, the classification, and the storage of a vast amount of knowledge, all contained in an electronic corpus of spoken and sung audio contents in Sardinian language. At the same time, it can also lead to a high usability in terms of ease of reference as well as ease of query and communication. It natively supports the Qualified DC metadata schema and is compatible with the Open Archive Initiative (OAI) with the support of the OAI Protocol Metadata Harvesting (OAI-PMH).

The formalization of a structured metadata schema was reached through the creation of an application profile for the Qualified Dublin Core metadata schema, where customized qualifiers were added to the standard elements and qualifiers. Metadata in non-standard schemas could then be better represented.

Linguistic annotations were formalized as well through a metadata schema. Corpus interrogation was thus made easier and quicker, since it used the search tool provided by the KMS. This work leaves space for future research on ways to improve the service.

A dedicated Web site or the integration of this system in an institutional portal through an exploration interface would be particularly interesting. Another feature that could be implemented may be a virtual map where recordings could be explored by geographic location.

3.3 Construction Process

In this case study, the underlying goal was the rational organization of large amounts of data using the knowledge characterizing the various stages of a construction process (Argiolas et al., 2013).

We analyzed the objects and verified the structure. The KB that we used is very large and highly representative of the general knowledge. The analysis can be replicated on different data. We made sure that the breakdown of building products in the TD phase and the analysis of objects in the BU phase had been applied in the case study. The results are compliant with the general theory of the proposed mixed approach to knowledge analysis.

The breakdown process of building components in Elementary Products defines the reference elements which can manage the multimedia objects.

The Elementary Product:

- is a classification that can be used to define formalized metadata;
- groups all the multimedia objects in a single semantic object;
- makes users select information in form of folksonomies tags;
- can be connected with other concepts like designer, project manager, etc.

The Elementary Product is the core concept of this knowledge; every instance of a single building project, and also the construction process, can be managed using this semantic concept.

The formalized information are the metadata defined for the Elementary Product. All remaining information, like technical data or data sheets (e.g., for a PVC window), can be found as information associated with the Elementary Product, and the descriptive data regarding the project can be represented as a folksonomy tag.

The structural information of the Elementary Product is represented as metadata, as well as the “Project Name”, “Phase”, “Technical description” and “General Description”, where the relevant information of the project selected by the user can be found. With this approach and formalization we can manage all the relevant and embedded information.

The management of very complex knowledge is a well known problem in Knowledge Management research; the technical and multimedia information are varied and contain interesting embedded information. The solution proposed is based on the very interesting concept of Elementary Product, which guides the knowledge organization process.

This knowledge formalization suggests its implementation in a KMS such as DSpace using metadata schemas. Further studies could analyze the results obtained using this system, so that this experience could be used to define further interesting information that can be formalized as metadata associated with the Elementary Product.

3.4 Italian Wines Reviews

The spread of the Social Web is significantly influencing the evolution of Semantic Web: users themselves are creating rules for the representation of information. The Web structure grows and changes, giving the user the chance to actively contribute to the development of the Web. For this reason, our study took into consideration this feature with the standardization of UGCs, trying to link the two worlds of Social Media and Semantic Web. Also the main search engines (Google, Yahoo, Bing, etc.) and the main Social Networks (YouTube, Facebook, Twitter, Flickr, etc.) are evolving, specializing, and interconnecting themselves on data retrieval, presentation, exchange, and sharing. That being so, the basic idea of our study was to propose a solution to the problem of the Web contents, present in different Web sites but belonging to the same knowledge domain. These contents have to be classified in the previously mentioned taxonomy, also using ad-hoc mapping rules.

We applied our approach to the KB of Italian wine reviews. From the analysis of the KB on the Web and the Google Ranking of many Web sites, we chose a list of some suitable and representative ones, so considering their popularity and reliability (Pani et al., 2013).

The taxonomy we created allowed for a definition of the reference knowledge which could then be managed as an actual usable knowledge, fostered by all the information existing on the selected Web sites.

We chose to validate the resulting taxonomy by verifying how the KMS allowed to make the acquired knowledge usable and accessible to the systems compliant with the Ontology of Wines. We validated the taxonomy by analyzing the content in other Web sites of Italian wine reviews, underlining how, in this case as in the previously described ones, the collected information could be represented and managed on the KMS through some simple mapping rules.

A further, interesting development could be the creation of repositories, able to collect the information previously classified and, through an ad-hoc system, they would be presented to the final user in a structured and customized way, depending on the requests, and possibly developing a graphic interface which could be able to draw as well as to arouse the curiosity of the user.

4 INDUSTRIAL EXPLOITATION

A very interesting example of industrial exploitation still under development regards the results of the research on ontologies in UGCs. The ontology contains all specifications to create a multimedia content management system able to manage information from UGCs as georeferenced multimedia contents.

The platform can manage UGCs, making them usable in an aggregated way. In fact, it is possible to use the ontology as a basis on which a system can be created, which will allow to search and classify multimedia content with a semantic reference given by the ontology, making data usable.

The ontology was particularly apt to make order in a wide and complex knowledge field such as the one pertaining to descriptive metadata used for multimedia content. In this context we can find a large number of different standards, some proprietary, some even with no regulation at all, which makes things difficult to people who want to work in that field. Tackling the issue of mapping made light on how working in this field would be much more efficient and convenient if one could refer to shared standards instead of proprietary ones, as it usually happens.

The project sets some specific extractors to be developed for each UGC source in order to power the platform. The extractors would follow the dates of the ontology, and implement mapping rules defined at the semantic level, and so would be able to retrieve the contents from UGC repositories and transform the information associated to them into manageable information in the platform.

Thanks to the modelled concepts, the platform would thus offer to users the opportunity to use the contents coming from various sources, already gathered, aggregated and geocoded.

The use of such contents could be possible through an application capable of showing aggregated data either by type and by location. Were the use of the contents to be performed with a smartphone or a tablet device, it could be extremely strategic to show them as Points of Interest (POI) located near the user, exploiting georeferenced information and the Global Positioning System (GPS) function of the devices.

The results of this research are the basis of a software platform allowing different customers (content producers, public administration, communication companies, public service suppliers, etc.) to develop added-value services based on georeferenced multimedia contents.

The users of such services could interact with the platform using the data which are already there, as well as show their preferences and adding their own contents. The platform is based on an enabling technology which gives the proponents the opportunity to enter an emerging, highly innovative and not yet covered market, that is the one of UGC-based georeferenced contents. They would have a solid starting ground for a complete, articulated and definitely wider business solution offer.

The platform itself is the vital element, on which a number of solutions can be defined depending on the contents the client has, which would be distributed according to their own business models.

The reasons behind this project are connected to a business opportunity born from many factors, among which the widespread mobile information devices such as smartphones and tablets that have mapping features (Google Maps). Users who are interested in receiving information on the places they are in, thanks to the UGC, could receive information that are much richer than the traditional POI present in the current systems.

5 CONCLUSIONS

Through our studies, we could see how a mixed-iterative approach made of TD and BU analyses of a knowledge domain could be efficient when formalizing knowledge.

Our approach to Knowledge Management is a simple process of applying a systematic analysis to capture, structure and manage knowledge. Our real goal was to make interesting knowledge available for sharing and reuse, and we focused our attention on interesting information on the knowledge domain which had to be represented.

In all the case studies we used, we studied a process to identify existing formalizations and knowledge sources within the domain, paying attention to multimedia objects. Valuable knowledge was represented into explicit form through formalization and codification of information, in order to maximise the availability of knowledge.

At the end of these analyses we defined a formalization, in form of ontologies, taxonomies, metadata schemas, able to represent the knowledge of interest for the domain.

As a final remark, we can notice how such a process could lead to many different solutions for formalization. We used ontologies, taxonomies and metadata schemas to formalize knowledge. The concept of metadata is clearly vital, also because it is easy to represent for operational purposes. In fact, metadata are very suited to being represented through different standards (RDF, OWL, etc.), and managed with many tools (DataBase, KMS, CMS, etc.).

A mixed approach, already proposed in the literature, means surely a demanding manual analysis work, but some Knowledge Engineering activity is necessary to represent knowledge. As regards the TD phase, the number of formalizations coming from ontologies, taxonomies and existing standards allow an articulated structuring of knowledge. Such representations are unlikely to represent the same knowledge we wanted to represent for our purposes: for this reason, they are very useful in a TD analysis but cannot be used as-is to represent our knowledge of interest.

At the same time, basic knowledge is seldom natively structured; it usually contains a large amount of information that can be extracted from it, formalized, then used and enclosed in a representation of knowledge. In particular, contents on the Internet can be a source of raw knowledge where some information can be acquired. Such information could then be formalized and acquire a remarkable value. An example of that may be the studies on UGCs and on the reviews of Italian wines that can be found on the Web. In fact, even Semantic Web tools proved unsatisfactory in managing this kind of issue.

Another important example could be the analysis of the information contained in multimedia objects pertaining to the ASAS and the construction process, where the sheer quantity of available resources and rich information would have been very difficult to manage without a formalization. The formalizations made it possible for domain experts to locate the truly useful information in the operational context and classify them, with the purpose of managing and sharing them through a simple KMS like DSpace.

The most important result we achieved with our studies was the opportunity to make this disparate knowledge available and manageable. In the current market, exploiting existing knowledge is a mainstream business, but in order to exploit it, one must be able to manage it first.

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