OpenFING: A Platform for Video Semantic Annotation as Learning Approach

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Abstract— The video-recording of traditional lectures is a low-cost activity for teachers and a supplement for courses with a high number of students. Also, videos can become a helpful tutoring resource. With these ideas in mind as motivation, we developed OpenFING, a Semantic Web based collaborative platform for video annotations. In this paper we present this platform, which allows students and teachers to create video fragments, add annotations, and provides searching mechanism over structured metadata.

Index Terms E-Learning, Video Annotation, Semantic Web, Linked Data.

I. INTRODUCTION

In Uruguay, the Instituto de Computación is the research and teaching center in computer sciences (CS) at the Universidad de la República (UdelaR). It is located within the Facultad de Ingeniería (FING, Engineering School) and is responsible for all the undergraduate and graduate programs in CS in UdelaR. As many Latin America schools, FING is experiencing an increase in matriculation rates and scarce resources, observing low graduation and high drop-out rates. New strategies have become necessary to adapt the scholar system to this reality.

The video-recording of traditional lectures is a low-cost activity for teachers and it can be seen as a supplement for a traditional course. According to some studies, recorded lectures can become a helpful tutoring resource, mainly because videos have a slower, more step-by-step lecture style than the classroom lectures; student use of videos is voluntary and can be tailored by students to meet their learning and topic-review needs, and can occur when and where students learn most effectively [1].

In this work we present OpenFING, a Semantic Web based collaborative platform to publish and annotate videos. With this platform, teachers and students can annotate videos with topics, comments, web resources, and other kind of metadata to improve their teaching and learning activities. One of our main concerns, from the technical point of view, was to develop an architecture in which new features could be easily introduced to the platform. This lead us to the use of Semantic Web (SW) technologies [2] to develop the platform, in particular Linked Data paradigm [3].

The rest of the paper is organized as follows. We start in Section II describing OpenFING functionalities. Then in Section III we discuss on related work. In Section IV we describe the OpenFING platform. Finally, in Section V we present conclusions and in Section VI current and future work.

II. A WALK-THOROUGH OPENFING

In this section we present OpenFING functionalities via a set of use cases. Along the description we refer to the screen capture presented in figure 1. Italicized terms refer to screen sections.

A. Search and find.

A user starts the session selecting a course in the Course Menu. Also, the Search Box can be used to perform queries. Queries input may be plain text (e.x. “induction”) or contain tags to refer to specific objects in the platform (e.x. course:, lecture:). Then, the search is performed using a combination of SPARQL queries and text search on the labels and titles values. In our example, the search for “induction” returns a video lecture where the title “Inductive Set Definitions” matches the search criteria. This video contains the complete lecture about the concept he is looking for, but also other related concepts.

B. Fragmentation and annotation.

While the user is watching the video, he decides to mark the video fragment where the teacher defines the “Declarative View of Inductive Sets”, and annotate it with the topic “Declarative view”. To do this, he uses the Annotation Type Selector to declare the type of the annotation as a “Topic”, and then he writes the topic in the Fragment Creator text area. At this time, the fragment start time is recorded. When the user pushes the blue button, the end time is recorded and the video fragment and its annotations are saved. Both objects are associated with the user. In the system, video fragments are identified by URLs which follow the Media Fragment URI 1.0 recommendation of W3C.

C. See annotations of other users.

While the user watches videos, he can also see annotations created by other users in the Annotation Viewer. These annotations appear dynamically as the start time of related fragments is reached. When the user clicks in an annotation, the related video fragment starts in the player.

D. Using external resources.

OpenFING may coexist with learning platforms, such as Moodle. Users may then also annotate video fragments using URLs that refer to lecture slides, or questions in a forum. This mechanism also allows to add reference to any URL on the Internet, in particular to add references to other video...
fragments in OpenFING, and was developed at zero cost because the use of standard dereferenceable URIs.

E. Recommended videos and resources.

While users watch videos, related videos and resources are shown in the recommendations panel (Fig. 2), which is accessible from the View Selector. The contents of this panel change dynamically according to the annotations found in the video. The recommendation criteria implemented so far is very simple, and retrieves video-fragments that refer to the same topic, but other criteria can be easily added to the platform.

F. Teachers Activities.

Students may use OpenFING without involving the teachers, but their participation may improve the experience. For example, teachers can curate users annotations assessing its correctness, or help in the organization of topics according to some taxonomy. Also, teachers can evaluate the comprehension of a certain topic by checking the annotations created by students. Finally, teachers can also propose the creation of annotations as a learning activity, as suggested in [4].

III. RELATED WORK

Some works deal with the use of annotations in e-Learning. In [4] the authors review a set of learning experiences that use annotations, and extract some recommendations about the use of annotations as a learning activity. In [5], an experiment about social annotation in an educational environment is presented which concludes that is a good way to promote the student engagement in the educative process. None of these works deal with video annotations. Several works treat video annotations, but only a few focus on educational videos. The work presented in [6] is close to OpenFING, but they do not use Semantic Web Technologies. About the use of Semantic Web technologies in e-Learning, some works should be taken into account. OpenCourseWare (OCW) Universia Team experience about producing and consuming Linked Data is presented in [7]. The paper introduces LOCWD, a vocabulary to describe OCW resources. In [8] a platform with some similarities to OpenFING is described where the search mechanism exploits LOD.

IV. OPENFING: A SEMANTIC WEB BASED PLATFORM

OpenFING is strongly based on SW technologies. Its data model is composed of two ontologies, and the video fragments and annotations are recorded as RDF triples in a triplestore. This allows to exploit data via SPARQL queries and reasoning strategies like Entailment Regimes. In the following sections we present the designed ontologies and the architecture of the OpenFING platform.
A. Design decisions

OpenFING is a collaborative platform to publish, watch, search and annotate videos. It is based on the following assumptions:

- **Each video is a set of video-fragments**, and each video-fragment is linked to a set of annotations.
- **An annotation implies a link between fragments and the annotation itself.** This links are dynamically created by human users or by software agents (e.g., Semantic Enricher in fig. 5). The set of annotations linked to a fragment are metadata tracks for the video.
- **Data can be represented as a distributed graph.** This graph is distributed because some parts might be in different servers with a decentralized management.

The aforementioned characteristics lead us to implement OpenFING using SW technologies. We now briefly describe some of the benefits of this approach with respect to traditional database technologies.

- **Our vision of data is a graph.** So, SW technologies like RDF provide a natural way to manage these data. In a relational database we need to map this vision to tables.
- **SW technologies simplify a distributed model.** These technologies allow us to distribute data among different sites. For example, the interaction between several instances of OpenFING platform can be easily implemented using SPARQL federated queries.
- **SW simplifies the extensibility of the data model.** In SW, adding new things is simpler than in a relational approach. For instance, adding a new attribute in a table may impact all the tuples in the table. Although this can be solved with a more complex design, this usually implies greater maintenance and operational costs. On the contrary, in the SW approach only the objects that refer to this new property are modified.
- **SW simplifies the interoperability with other systems.** External systems and users can obtain data via querying the SPARQL endpoint.

B. The Data Model as Ontologies

OpenFING data model is composed of two OWL2[9] ontologies: a generic vocabulary about video-fragments and its metadata, called MMC, and a specialization of the former to include some particularities of social components, called OFM. MMC is a specialization of the W3C Ontology for Media Resources[10], an it includes concepts like Media, Metadata, Topic, etc. OFM includes concepts like University, Teacher, Lecture, Course, etc. Figure 3 presents the main components of the OFM ontology while Figure 4 shows an example that illustrates how this ontology is used to represent data and represents the annotations built by two different users (Lucia and Carlos). These annotations refer to different courses, so, different fragments on different videos, but both annotations refer to the same topic.

OFM is aligned with standard vocabularies and ontologies like W3C Ontology for Media Resource, the Academic Institution Internal Structure Ontology (Aiiso) [11], and the Friend of a Friend Vocabulary (FOAF)[12]. Usually, Linked Data based systems use terms from different vocabularies. We think that this strategy delays the development because it is difficult to use all terms in a correct way. We choose to define our own terms in the design of our ontology and then map its concepts on standard vocabularies using rdfs:subpropertyOf and rdfs:subclassOf relationships. This strategy allows us to publish a SPARQL endpoint which can resolve queries using terms of standards vocabularies, while we use our ontology to define the data.

C. Architecture

Figure 5 presents the functional architecture of OpenFING. The main component, **OpenFING server**, acts as an application proxy and a wrapper over the triplestore by implementing the access following the datamodel. The server exchanges mostly JSON structures with the client using HTTP, and uses SPARQL protocol to access to the triplestore. The **Annotations** component is implemented as a RDF triplestore. These annotations can be either generated by users, via the client application, or semi-automatically by the Semantic Enricher (SE). This component searches relevant resources in the web using techniques from areas like Natural Language Processing, Machine Learning, Data Mining. For example, it can add a reference to the DBPedia page about a certain topic.

**OpenFING Client** is a web interface built on top of HTML5 and Javascript, that takes advantage of HTML5 video and
track tags. Finally, the Videos component can be distributed over different websites, because the client only needs the video URL to use it. The platform is still under development, but we have some early prototypes.

V. CONCLUSIONS

In this work we presented OpenFING, a Semantic Web based collaborative platform to publish and annotate videos. With this platform, teachers and students can annotate videos with topics, comments, web resources, and other kind of metadata to improve their teaching and learning activities. The development of video-lectures is usually considered as a high cost activity for teachers. Our low-cost approach, based on the publication of video-recorded traditional lectures, has still proven to be useful to students.

We also believe that our approach actively promotes the involvement of students in their learning process, since annotations and video-fragments are mainly added by them. In this sense, our approach is aligned with the ideas proposed in Blended Learning strategies[13].

From a technological point of view, we believe that Semantic Web technologies allowed us to develop a flexible environment, in which we can add new features in a simple way. We also think that HTML5, JS, NodeJS, SPARQL stack works as a good prototyping platform since it reduces programming and testing times.

VI. CURRENT AND FUTURE WORKS

The development of OpenFING is still a work in progress. New versions of OpenFING server and clients are being developed using NodeJS and HTML5. In the near future we expect to extend the Semantic Enricher component using two approaches: querying LOD, and using Natural Language Processing of documents. On the educational dimension, we are starting to develop strategies to study the effects of using OpenFING over students and teachers.

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REFERENCES