External Resource Annotation Framework and its applications in E-learning

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Abstract. Rich Internet Applications that enable new ways of interaction with digital objects within multimedia scenes become important for educational communities. Such new ways of advanced human-computer interaction, in its different forms match the needs of formal education as well as lifelong learning in medicine, architecture, construction or cultural heritage management. This paper presents innovative multimedia annotation methods based on advanced human-computer interaction and (a)synchronous interpersonal collaboration features, focusing on e-learning activities. They have been implemented within eRAF (External Resource Annotation Framework) with the scope of going beyond the existing solutions by introducing new annotation types using external resources. Thus, anyone can easily annotate the own resources with additional information such as real-time handwriting, text and animation, or even audio/video sequences stored into public data repositories, or recorded ad-hoc, in order to create value-added interactive content.

Keywords: human-computer interaction; e-learning; interactive training; multimedia; video collaboration; annotation; framework; mobile agent

1 Introduction

Rich Internet Applications (RIAs) combine the Web's lightweight distributed architecture with desktop applications' interface interactivity and computation power, then the resulting combination improves all the elements of a Web application (data, business logic, communication, and presentation) [15]. This new approach improves the user experience with more powerful interfaces and enables new ways of interaction with digital objects within multimedia scenes. RIAs enhance the traditional paradigms of web applications by breaking away with the idea that a "screen", or a client state, is essentially a web page defined by its URL [16].

E-learning has become an important way for enhancing the learning and teaching processes. With the rapid development and spread of online learning platforms, distance learning became not just a simple alternative to traditional education but its viable complementary method while blended learning is to be adopted by more and

more educational organizations. The advantages of e-learning platforms have been extensively highlighted and analyzed in different educational disciplines (e.g. [2], [6]). Rich Internet Applications that enable new ways of interaction with digital objects within multimedia scenes become important for educational communities.

Multimedia annotation systems facilitate the synchronous and asynchronous interpersonal collaboration and human-computer interaction. The term Human Computer Interaction (HCI) has been in widespread use since the advent of the IBM computer for personal use in the mid-1980s [9]. The process of designing and building the User Interface (UI) is thus a very important aspect, since many users identify the software product with the UI. Advanced HCI methods such as annotation and online collaboration, by natural forms of communication, should improve the quality of interpersonal interaction and enhance the learning process. The synchronous and asynchronous communication represents a critical feature for web-based systems, especially when multiple users simultaneously annotate the shared resource. Annotation tools are widely spread in the computer-supported collaborative work while their definition depends on the application domain.

External Resource Annotation Framework (eRAF) introduces a new annotation type, external resource annotation, and a SCORM compliant rendering tool for complex resources. The external resource annotation consists of the original object completion with an external resource stored into a public repository (Youtube video sequence, e.g.). In other words, eRAF allows the completion of an internal resource with an external one in order to express the conceptual meanings of an annotator's implicit thoughts. The external resource is identified by a mobile agent handled by the eRAF Multi-Agent Platform and its reference is stored into eRAF External Repository.

This paper presents the eRAF main concepts and its applications in e-learning. The eRAF customization for e-learning focuses on creation and delivery of value-added educational content, as well as knowledge assessment. In the educational domain offering additional explanations during courses is a real need. These additional explanations actually represent different external resources like videos, images, recent reads from other sources that have an important contribution to the educational process. From the learner's point of view, the annotations not just help to get the focus on, but also to improve the learning manner and increase the retention factor, so, its presentation and organization mode is very important and it is typically the instructors' and learners' responsibility. Knowledge assessment is also a critical part of the educational process. This way, the eRAF framework can be customized in order to embed assessment processes within different types of serious games.

The paper is structured as follows: Section 2 presents a list of relevant annotation frameworks used in the educational context, highlighting their main advantages and limitations. Thereafter, Section 3 illustrates the open-architecture and the main concepts used for the design of the proposed collaborative multimedia annotation framework - eRAF. Section 4 highlights the high feasibility of eRAF and its customization for education and training, focusing on providing new methods of creating, sharing or assessing valuable educational content. Section 5 presents a series of experimental results of eRAF applications in e-learning, while Section 6 is allocated for conclusions and further development.

2 Related Work

Section 2 presents an incomplete, but representative list of web annotation tools and frameworks for collaborative learning. Annotations may enhance user's attention and organization during the learning process. End-users have the possibility to construct their own knowledge and concepts by annotating shared educational resources. Many studies highlighted the advantages of multimedia annotations. Reference [3] presents a list of important state-of-the-art requirements for annotation systems that are to be adopted by the virtual communities. Taking into consideration these requirements and the fact that these systems need to support a high degree of interaction, the authors further analyze several annotation frameworks and e-learning platforms like Teamware [3], LEMO [4], PAMS [5], Annomation & SugarTube [7] and Learning Café [8].

LEMO [4] implements a uniform standards-based annotation model for multimedia contents and supports various types of annotations. It is mainly focused on the digital libraries domain and annotation of cultural online assets, defining annotations as metadata. LEMO addresses fragments of various content-types in a uniform, interoperable manner and pulls annotations out of closed data silos making them available as web resources to be accessed by other web-based systems.

The advantages of multimedia annotation-based collaboration in e-learning are highlighted by PAMS 2.0 [5], a web-based environment focused on knowledge sharing in computer-supported collaborative learning. PAMS provides annotation techniques for several content-types like PDF format, Microsoft Word and HTML pages. Although the system manages text, image or voice annotations, it doesn't allow the user to annotate an object with an external resource neither to add nested annotations. PAMS allows defining associations between internal annotations, saved into the system, but not annotations using external resources stored into public data repositories. In addition, PAMS offers access control without reconfiguration of access rules for annotators.

Teamware is a web collaborative annotation and editing environment, which enables unskilled end-users to quickly train and easily use annotation tools and templates [3]. Each resource in Teamware is converted to internal annotation format, then the annotations are exported in XML structures. In contrast with LEMO and PAMS, Teamware enables both manual and automatic text annotations.

Yu and al. in [7] describe a video annotation and browser platform with two online tools: Annomation and SugarTube, an approach to semantically annotate and search educational video resources using ontologies defined in the Linked Data cloud. As highlighted by the authors [11], ontologies and vocabularies provide the foundation for educational resources annotation in a machine readable way and encourages semantic connections between resources. The importance of publishing online educational resources that can be easily discovered, integrated and reused is growing and Linked Data is a key constituent of this growth. There is already a significant number of educational datasets that are currently published as Linked Data by universities, government institutions, publications and specific projects in this area [17]. This is why another important advantage of SugarTube is that it allows linking videos with other educational resources from the Linked Open Data cloud and the web.

An annotation in Learning Café [8] is a piece of data (e.g. text, image) attached to a fragment of a video. This semantic multimedia learning platform goes beyond the traditional training methods and helps staffs to acquire new skills for their professional experience. The platform recommends training videos based on user's profile and allows end-users to annotate the videos, generating resources that are defined in terms of the SCORM standard. By sharing, reusing and linking SCORM compliant educational web resources, platforms like eRAF and Learning Café allow content authors to share their content to a variety of other e-learning platforms.

Most of the advantages and disadvantages highlighted in this section were taken into consideration when elaborating the eRAF modules and components. Same as LEMO, eRAF implements segment-based annotations and allows the end-users to annotate different parts of the shared educational resource such as sections of a document, slides of a presentation or selected frames in a video sequence. Also, associations can be realized by using external resource annotations. For instance, a phrase from one document can be compared with a phrase from other documents or a digital resource can be annotated with a relevant part of a video sequence. The flexibility of eRAF facilitates the integration with other frameworks in order to increase the degree of HCI by creating different types of annotations and focusing on interpersonal collaboration. Nevertheless, these state-of-the-art requirements have been used when designing the open architecture and performing the experimental results during the implementation and customization of eRAF.

3 eRAF Open architecture

eRAF (External Resource Annotation Framework) is a multimedia annotation framework which supports advanced human-computer interaction and (a)synchronous interpersonal collaboration. The newly proposed framework defines the annotation elements as text, voice, image or video and introduces a new annotation type, called external resource annotation. eRAF aims to provide a general purpose for multimedia annotations in order to create value-added multimedia content for multiple application domains.

In the eRAF context, the synchronous collaboration feature offers meaningful interactions during live sessions, providing end-users multiple ways of interacting, sharing and possibility to collaborate, ask questions and even annotate resources in real-time. The interpersonal collaboration within the framework is also sustained by the reply threading feature. Therefore, nested annotations are allowed.

An external resource annotation represents the completion of an internal resource. Once identified, a reference to the external resource is stored into the eRAF External Repository. In addition, the framework provides a SCORM compliant rendering tool for multimedia content. In eRAF context, the multimedia content consists of multiple resources that are stored either into the application internal repository or into other public cloud infrastructures (such as Youtube, Vimeo, etc). Thus, the value-added resources generated through annotations are also available as SCORM compliant web resources to be accessed by other online systems.

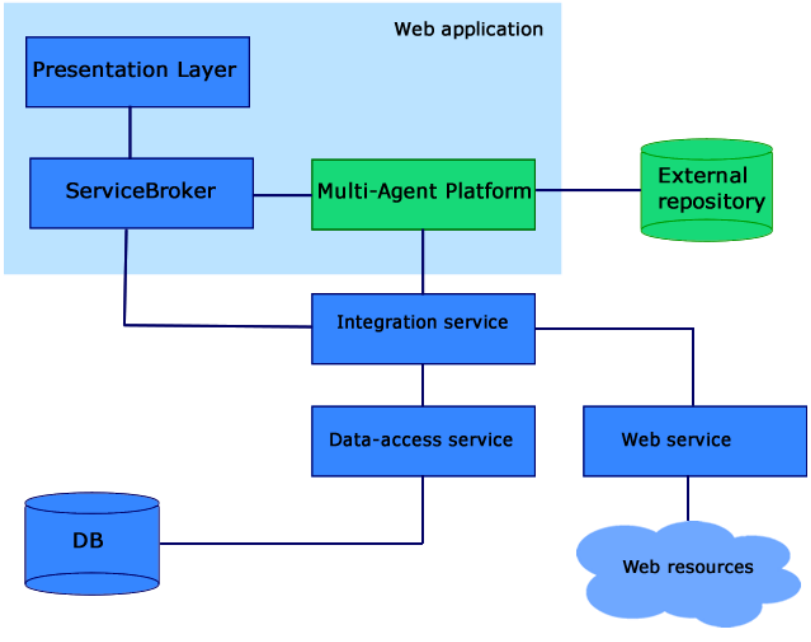

Fig. 1. eRAF Open Architecture

Even though external resources are rendered within eRAF, copyright protection for public resources is also an important feature taken into consideration when designing the framework. The external resources are not actually saved into the system, but a reference and metadata (URL, duration, other details) are saved into the External Repository. Even if the referenced resources are watermarked by default for intellectual property or not, eRAF always displays at least the URL of the public cloud infrastructures which represents the source of the referenced resource.

eRAF open architecture is illustrated in Figure 1. eRAF complies with the SOA architecture [10] and consists of decoupled modules that communicate and collaborate based on an advanced interoperability mechanism. In addition, the front-end components implement enhanced interaction methods, while the executive layer implements a complex business logic. Multimedia resource annotations are rendered by a complex Canvas-based container, the main component of the Presentation Layer able to aggregate and render all types of external and internal resources. As shown in Figure 1, the Presentation Layer components independently invoke the business logic according to a well-defined mechanism, implemented by ServiceBroker, which ensures the command and control message exchange. Nevertheless, the ServiceBroker also hosts different web services responsible for annotation as well as the IntegrationService that handles the Multi-Agent Platform mapping and interoperates with the dedicated web services.

The Multi-Agent Platform and the External Repository components implement the newly proposed annotation approach. Thus, the main functionality of the Multi-Agent Platform is to identify the most appropriate resources to be used for annotating the

current materials and creating value-added content. If the identified resource is stored into the eRAF database (DB), the Integration Service should invoke the corresponding Data-access service for creating the link between the identified resource and the annotated resource. If the requested resource is an external one, the intelligent agent queries the External Repository in order to find some information regarding the mentioned resource. Whether this information is not retrieved, the mobile agent invokes a web service that searches for resources from public repositories.

Yet, another important aspect regarding the external resource annotation process is the resource identification and reference saving into the local storage so that each time the end-user wants to review an external resource (e.g. video) the annotation is correctly rendered. In this context, the role of mobile agents becomes very important – the integration of Multi-Agent Platform with the annotation modules ensures the further development of advanced resource discovery, data transfer and management techniques. When adding a new external resource annotation, a mobile agent instance is created. This instance searches the web for existing resources that match the user's requirements expressed by means of different key-words. If a reference to the external annotation is already saved into the External repository, then the mobile agent directly invokes the public resource and cancels the web searching process. The use of intelligent agents for retrieving external resources and annotating the educational content has a high impact to the application storage space since the external resources are not downloaded and stored into the eRAF data warehouse. Once the resource is retrieved by the intelligent agent, its URL is saved into the eRAF External Repository in order to be published and displayed using the eRAF rendering tools. Whether a certain resource is deleted from the public repository, so the educational content is not relevant anymore, the eRAF External Repository automatically detects the change, notifies all annotators that already used it about the inconvenience and delegates a mobile agent to search the web for similar resources for replacing the removed one. If the content of the annotated resource changes, the annotators are notified, ensuring that even though the document changes the annotations do not change, so they are not deleted.

Conceptually, this framework identifies three types of entities that can be defined based on a limited set of attributes:

- Resource (N, A, C, P), where N represents the unique identifier of the resource within the general context of use. It has an author (A) able to share it with other users (if the privacy attribute – P – is set to public) and a static or dynamic content (C).
- Annotation (N, T, A, L, [A_i, $i = \overline{1,k}$], G), where N represents a unique identifier and (T) is the annotation type that defines its origin ("TextAnnotation", "ExternalResourceAnnotation", "VideoAnnotation", "ImageAnnotation" or "VoiceAnnotation"). An annotation is created by a specific author (A) and saved locally within the eRAF database or generated from external public repositories. This means that the location (L) is very important (internal or external). The Multi-Agent Platform searches these repositories for the appropriate annotation, requested by the user by means of a key-word. Nested annotations are also supported, thus an annotation may integrate *k* inner annotations represented as [A_i, $i = \overline{1,k}$]. It is important to identify some of the graphical attributes (G) that are attached to an

annotation, such as: X, Y position, size, resolution (when using video annotation), color, etc.

- User (N, [R_i,$i = \overline{1,r}$]): such an entity is defined through a unique identifier (N) and a set of rights (R) that enable specific operations on the current context.

4 eRAF Customization to E-learning

According to the new trends in education and training, eRAF presents innovative multimedia annotation methods based on advanced human-computer interaction and (a)synchronous interpersonal collaboration. They aim to improve the instructors' and learners' experience both parties being able to collaboratively explore and share valuable ideas and knowledge.

The general object diagram illustrated in Figure 2 presents the eRAF structure and highlights the manner the end-users interact with the digital resources and how annotations can be created by different types of participants to the educational/training process. Two types of end-users can be defined in eRAF: annotator and supervisor. The supervisor is an annotator having extra privileges/rights such as edit previous annotation, create new shared document, etc. eRAF provides an uniform general annotation model that can be extended regardless of the digital resource type or the annotation mode for different application domains, like e-learning and online training. Nevertheless, the resource supervisor monitors all actions performed over a shared resource.

In addition, each supervisor is able to add a new digital resource, monitor annotators' actions, create, view or update the own annotations or other annotations associated with the shared resource. Every resource can contain different types of annotations, as presented in the object diagram (Figure 2): "TextAnnotation", "ExternalResourceAnnotation", "VideoAnnotation", "ImageAnnotation" or "VoiceAnnotation". Nested annotations are also allowed, thus an annotation may contain other annotations.

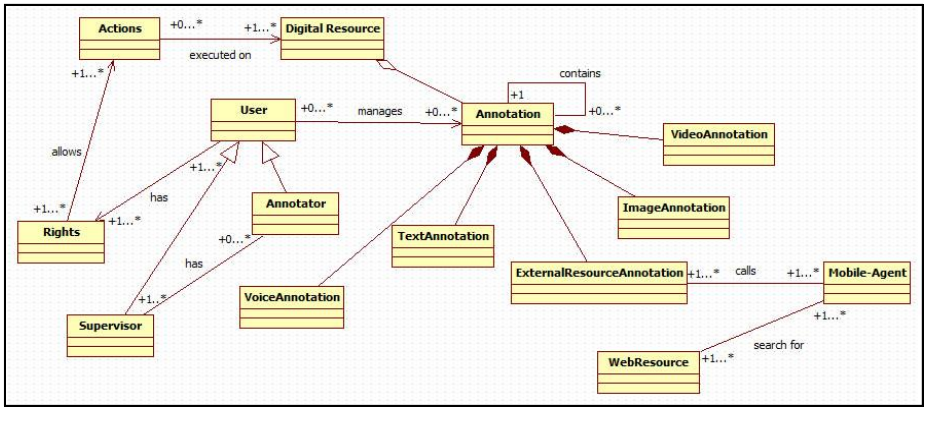

Fig. 2. eRAF Object Diagram

eRAF also allows the supervisor to manage annotation rights for shared resources without affecting the integrity of the annotated resource. For instance, if the supervisor removes the annotation privilege for a certain resource and the annotator already annotated the resource, then all the other annotators will be noticed about this change. The change will not affect the current annotated resource while all the previously created annotations are already saved into the system repository. This way end-users collaboratively explore and exploit valuable ideas and knowledge.

eRAF customization for the education and training focuses on two main priorities: value-added educational content and knowledge assessment. In such a domain, experienced participants such as experts, teachers, trainers, may provide their annotations to help end-users understand learning materials. In this domain, the instructor and learner represent the supervisor and annotator types. Offering additional explanations is a real need during courses or knowledge sharing sessions. They actually aggregate different external resources like video sequences, images, text, links, from other sources that bring an important contribution to the educational process. Learners can also annotate shared educational resources by adding remarks, comments, notes, explanations. Such annotations will be automatically reported by eRAF monitoring tools, then the educators (trainers, teachers) know exactly the progress each student/trainee does each time when accessing the resources.

Furthermore, eRAF focuses on knowledge assessment. The general eRAF annotation model can be customized for creation of assessment content and embed it within serious games used in the educational/training process. For example, digital puzzles based on random images from public repositories, connecting multiple points in order to obtain a certain geometric figure, highlighting correct query answers can be used within eRAF in order to improve the educational process.

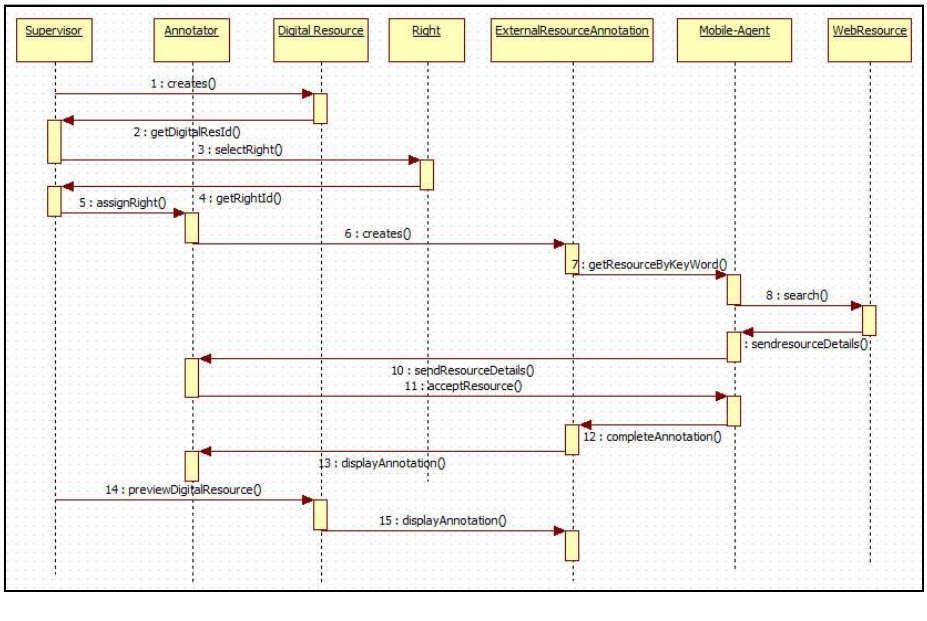

Fig. 3. eRAF - Add new external resource annotation sequence diagram

A sequence diagram explaining the external resource annotation process is illustrated in Figure 3. The supervisor/instructor creates the shared digital resource and assigns different rights to annotators/learners. When adding a new external resource annotation, the end-user has the possibility to type a list of keywords related to the subject of the annotation. The set of keywords is used by the Multi-Agent Platform that delegates a set of mobile agents for searching public repositories for web resources that match the keywords. The search results are sent back to the annotator for acceptance and used for next annotation activities. Once accepted, the external resource URL and metadata are stored into the External Repository.

The Multi-Agent Platform is based on JADE [12], a framework focused on the development of interoperable intelligent multi-agent systems. JADE organizes applications by defining two types of components: agents and services. The services are non-autonomous components whose operations are triggered by the agents. This approach fits the eRAF requirements since the multi-agent platform delegates a mobile agent to search into public web repositories for a certain resource representing the external resource annotation. The rendering tool for complex resources and the advanced human-computer interface are developed using HTML5, jQuery and jQuery Mobile (for the mobile version of the framework). Reference [13] describes the benefits and pitfalls of using HTML5 and related standards (e.g. WebGL, SVG, CSS3) for developing online systems. HTML5 is a suitable choice for eRAF and especially for multimedia content sharing like external videos or other complex resources. jQuery Mobile aims to deliver a uniform user interface and high-class JavaScript to a wide range of mobile devices. All prevalent operating systems, namely Android, iOS, BlackBerry OS, or Windows Phone, are supported. Mobile web tool create in jQuery Mobile can also be deployed as native applications with PhoneGap [14].

5 Experimental Results

This section presents a series of experimental results obtained using the eRAF prototype in the educational domain. By reading and making annotations, participants collaboratively explore and exploit valuable ideas and knowledge, adding value to the educational content by using different remarks, comments, notes, explanations (text, highlight, underline, asterisk, arrows, etc). eRAF customization for the educational domain focuses on two main directions: providing value-added educational resources and knowledge assessment.

Figure 4 illustrates the eRAF prototype used in education for knowledge transfer and (a)synchronous interpersonal collaboration. In general, annotations may help participants to improve their attention, organization, indexing and collaboration. Annotations may catch participants' attention thus help them focus on annotated concepts or subjects. In addition, annotations help participants construct their own knowledge and concepts.

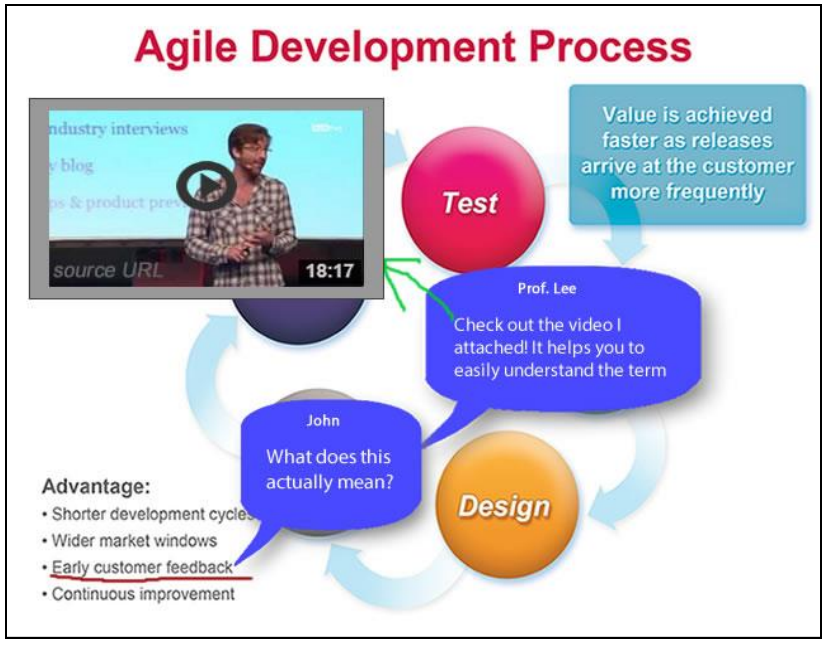

Fig. 4. eRAF prototype for educational domain

Furthermore, annotations could help participants bookmark annotated areas and use them as indexes or reminders for later references. As mentioned, PAMS 2.0 [5] (described in Section 2) is focused on knowledge sharing in computer-supported collaborative learning. It provides annotation techniques for several content-types like PDF, Microsoft Word and HTML Web pages. Although the system manages text, image and voice annotations, it can be improved with external resource annotations. For example, related public video sequences enhance the retention factor and facilitate a better understanding of some technical terms. One advantage of PAMS is that it provides access control, same as eRAF. Yet, it doesn't allow reconfiguration access rules for annotators. eRAF deals with the reconfiguration access control by introducing the digital resource supervisor able to assign and manage the annotation privileges for a shared resource.

Knowledge assessment is an important aspect of the educational process. As mentioned in the previous sections, the general eRAF annotation model can be customized in order to embed assessment and serious games in the educational process. Figure 5 presents a customization of eRAF for knowledge assessment using serious games like digital puzzles. In order to improve the learner's geographical knowledge, the instructor decides to use a serious game that besides geographical knowledge requires attention, organization and perseverance.

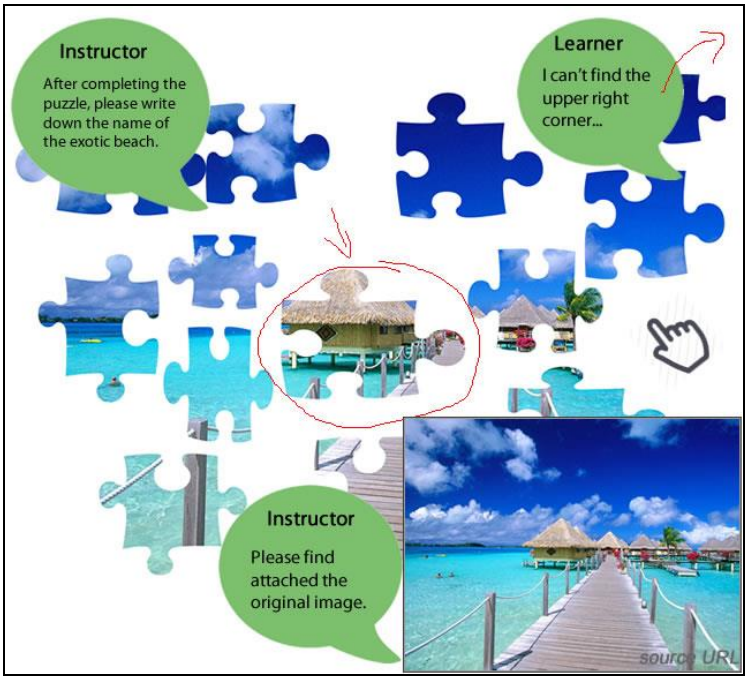

Fig. 5. eRAF prototype used in the educational domain – serious game example

6 Conclusions and future work

The goal of this paper is to present the eRAF framework and advanced multimedia annotation methods dedicated to (non)formal education. These new advanced human-computer interaction and (a)synchronous interpersonal collaboration features have been implemented with the scope of going beyond the existing solutions by introducing new annotation types using existing resources. Thus, anyone can easily improve the own resources with additional information such as real-time handwriting, text and animation, or even audio/video sequences stored into public data repositories, or recorded ad-hoc, in order to create value-added interactive content.

As further development, the research will focus on extending the framework functionalities by adding a controlled vocabulary component as well as spoken language understanding capabilities. This involves content checking and terms validation used within annotations, in order to fit the expectations of annotators that shared the same resources. The personal and public annotation concept will also be taken into consideration.

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