Social media interaction and analytics for enhanced educational experiences

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***Abstract*—In this paper we present an innovative system based on social media and high quality multimedia content delivery designed to enhance the educational experiences of students in cultural centers and museums. The system brings together students that are viewing an educational movie with a panel of experts that may be geographically dispersed, and engages them in an exciting social media experience via which they can interact with each other as well as with the remote experts. We employ appropriate methodologies for monitoring and analysing social network activity in order to extract valuable information from the social network activity and use it to seamlessly annotate in real-time the presented educational movie using anthropocentric semantic extraction based on MPEG-7. In this way, the multimedia content of the presented movie can be easily reviewed by multiple geographically dispersed individuals, and improved afterwards according to the received feedback, thus maximising the benefit for students, teachers and content producers alike.**

***Index Terms*—social media; multimedia content production and delivery; video annotation; educational movies; remote interaction**

I. Introduction

The emergence of Web 2.0 and the widespread use of social media have significantly changed our lives. New capabilities and potentials have been created to promote the development of educational communities of knowledge, to facilitate and improve the learning process. According to a study by the US NSBA [1] 71% of students say they use social networks (SNs) at least weekly. Both school district leaders and parents believe that SNs could play a positive role in students' lives and recognize possibilities and opportunities of SNs in education.

Recognizing the potential impact of social media on knowledge expression and sharing, Du and Wagner [1] sought to empirically examine whether the continuous use of weblogs would affect students' learning performance and its potential benefit as a knowledge construction tool and a social learning medium in university senior-level business education.

The integration of Web 2.0 tools in one platform, allowing learner tracking functionality, monitoring and visualization features, supporting grading and evaluation, obtained positive feedback after being deployed in a university undergraduate course [2]. Other platforms were created integrating features of online SNs [3] and supporting university students' learning activities, useful while they conduct collaborative projects [4]. The use of SNs as supplements during a course in order to deliver educational content to mobile devices showed their great potential to enhance traditional educational methods [5].

The use of Facebook within a high school science-mentoring program has positively affected the relationships between mentors and mentees and students believed that they have learned more by using SNs [6]. However several limitations impacted this research, such as the design template of Facebook pages, the necessity of participants to become friends in order to be more easily aware of others posts to the page, addressing future research in exploring a more beneficial design. In our system several components were created, based on the developed API, to support all interactions with multiple SNs, achieving SN transparency and facilitating interactions among participants.

An educational tool, utilizing a YouTube channel for video-casting recorded videos was presented [7] to tackle the problem of lack of space, time and permissions for university students' educational visits to industrial plants, proposing additional study on SNs potential on video sharing educational applications.

Studies have tried to bridge the gap between experts and the public, taking advantage of the popularity of SNs. They were used as an informal learning environment where students could meet with external guest experts [8], while in [9] experts tried to promote citizens' scientific literacy using a Facebook page for displaying content and social interaction. Similarly our system enables remote experts to interact with the public, besides using a page or group in SNs, with dedicated developed applications and to virtually attend the show and assist in the presentation in real time.

A system's prototype tried to facilitate group interaction (during and after a visit), exploiting the fact that visitors tend to visit the museum in small groups [10]. Museums and cultural centers have adopted multimedia and mobile applications have been developed to increase user involvement [11], while the investigation of SNs use in a cross-cultural collaboration project [12] focusing on a group of students concluded that SNs form a feasible platform for educational purposes and can be improved by integrating other Web 2.0 features.

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[1]www.nsba.org, "Creating & connecting, research and guidelines on online social and educational networking", 2007

According to McMillan and Chavis theory [13], the sense of community consists of four elements: membership (feeling of "belonging"), influence, fulfillment of needs and shared emotional connection. Through the proposed system, students can be part of an educational community of students, teachers and remote experts, created during the educational visit but remaining active after the end of it. The feeling of belonging to this community will foster their participation, leading to active students and enhancement of learning.

To this direction, this paper introduces a low-cost, distributed system that blends different concepts and technologies, such as high quality multimedia content production and delivery, social media interaction, and methodologies for monitoring and analysing SN activity, for enhancing the learning process via the presentation of educational movies in traditional cultural centers and museums. The presented system brings together the students that are viewing an educational movie with a panel of experts that may be geographically dispersed, and engages them in a social multimedia experience via which the students can interact with each other as well as with the panel of experts. Compared to our prior preliminary work [14], this paper presents an extended version of the system with major enhancements in feedback extraction from the exchanged social data and its use to seamlessly annotate in real-time the presented educational movie using anthropocentric semantic extraction based on MPEG-7. Thus, the multimedia content of the presented movie can be easily reviewed by multiple geographically dispersed individuals, and improved afterwards according to the received feedback. The system has also been extended with an innovative application based on Beacons (http://www.bluetooth.com/Pages/Press-Releases-Detail.aspx?ItemID= 201) for tracking the location of students at an exhibition at a museum or an educational venue and improving their experience by facilitating instant access to additional multimedia content available on the SNs as well as supporting interaction with remote experts for exchanging questions and answers. The proposed system has been successfully deployed and used in the Foundation of the Hellenic World (FHW) cultural center and received highly positive feedback from all involved entities[2] .

This paper is organized as follows. Sections II and III present the setup of the system that was deployed in the real-world cultural center settings of the FHW. Detailed descriptions of its main building blocks in terms of multimedia and social content are given in Section IV, whereas in Section V are presented details behind their integration and the way the system is used in practice. Another application of the proposed system is described in Section VI. Finally, conclusions are drawn in Section VII.

II. The Tholos Dome: A virtual reality installation for education

The curriculum of a course (e.g. history) usually includes visits to museums, archaeological sites, educational venues and virtual reality educational installations. Our purpose is to enhance the learning experience of students taking part in an educational movie presentation.

A setup of the system was deployed at Hellenic Cosmos, an educational/cultural center in Athens owned by FHW, allowing the interaction among students, teachers, venue's educators and remote experts. A series of exhibitions, educational, traditional and technological, are presented at the premises of Hellenic Cosmos. The most prominent among those is "Tholos", a real-time virtual reality (VR) dome theater, which is frequently attended by school groups as an extension to their history class. Tholos utilizes a fully digital projection system, configurable in a monoscopic, stereoscopic or a mixed mode of operation. Six pairs of seamlessly blended SXGA+ projectors project the synthesized imagery on a tilted hemispherical reflective surface of 13m in diameter. The auditorium is designed to host up to 128 students. The in-house developed engine used for creating the VR applications is described in detail in [15].

The Tholos VR system (before the launch of our experiment) is operated by a single user, namely the educator, via a joystick and manipulator tracker combination. Its operation may be modeled mainly as a one-way communication system, as the educator controls the system and the information rendered and projected to the students, while simultaneously orally commenting on it. As a sole exception to this, students can participate in specific electronic polls (through buttons embedded on the seats), which determine the path that the educator will follow, altering in real-time the flow of the presentation. The main reason for this extremely structured and predefined approach is that the educator is working with predefined scripts prepared by specialized experts (mainly archaeologists, historians and architects), since the cost of hiring real experts as museum guides is prohibitive. These scripts provide information in a specific order and therefore the tour in the VR world has to follow the same order, as the educators have little possibility to operate outside it. During the presentation, the students are not allowed to exchange comments with one another or communicate any questions to the educator since it would disrupt the movie flow and interfere with the experience of the other visitors. Even if they were though, the educator may as well not be in the position to provide insightful answers due to lack of in-depth expertise.

III. Cross fertilizing traditional VR education installation with SN

The aim of this system is to enhance the experience of the Tholos visiting students by cross-fertilizing the traditional VR education installations with social media and multimedia streaming, so as to provide a shared educational experience that brings students in touch with each other, the teachers, the educator, as well as other remote individuals with expertise on the field. In contrast to the conventional Tholos experience, the deployment of the described application over the FHW facility, as shown in Figure 1, enables the collaborative presentation of the VR content by streaming the content to a panel of remote experts, who may be geographically dispersed and by allowing them to "join" the educator, monitor and assist in the presentation, by providing specialized information. Simultaneously,

[2]http://www.experimedia.eu/2012/08/25/next-generation/

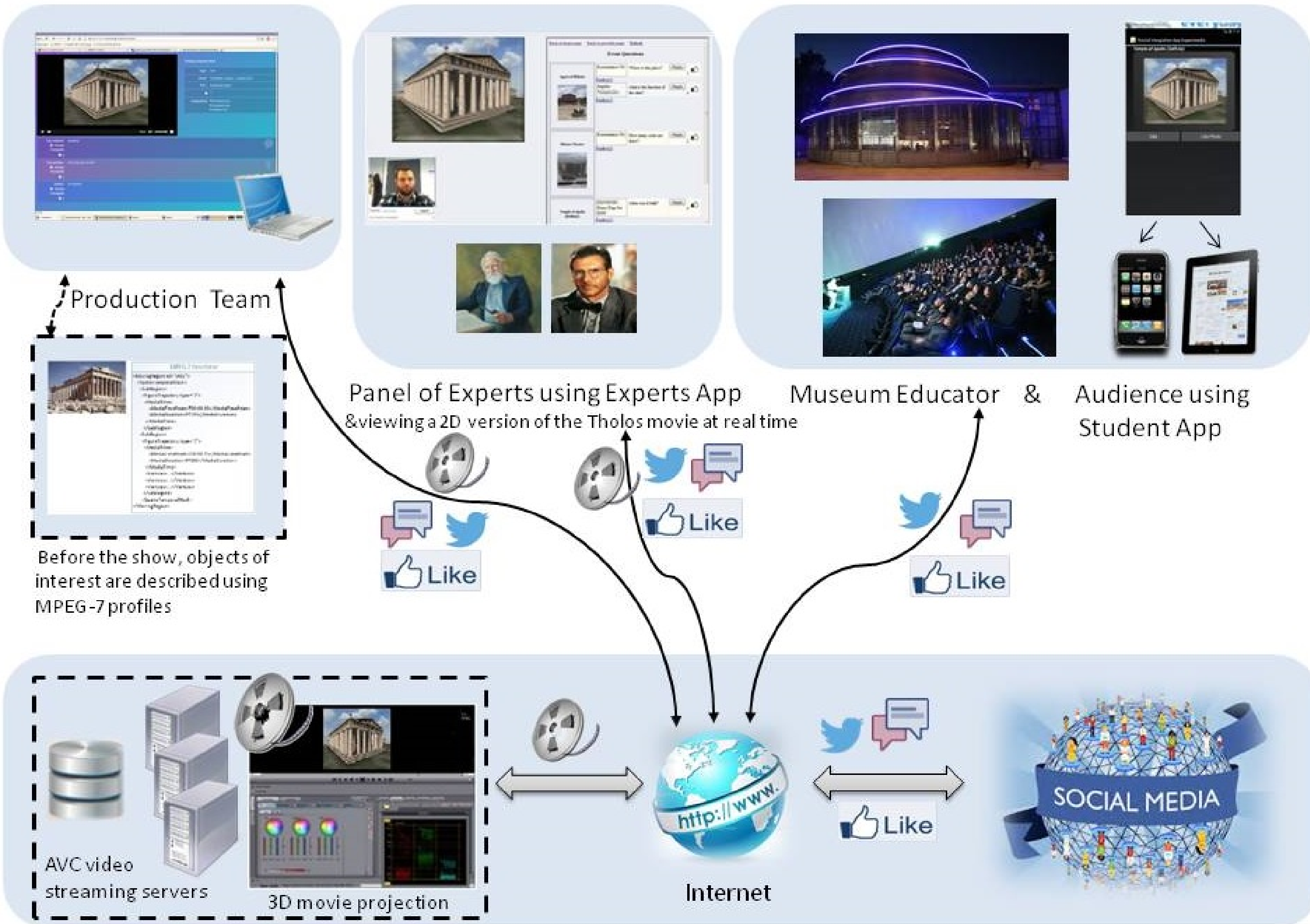

Figure 1. Proposed System Overview. Students visiting an educational venue and viewing an educational movie, by using Student Application, are brought together with a panel of experts, who receive the real-time streamed content and answer questions of their expertise through their Expert Application. Valuable information is extracted from the SN activity and used to annotate in real-time the movie, using anthropocentric semantic extraction based on MPEG-7.

the production team can use another system's application that collects and processes via monitoring mechanisms data from the participants' SN activity and use this valuable feedback to gain insight in the audience's opinion of specific parts of the movie and improve those accordingly.

IV. System's applications and services

A. Social content applications and services

Social content applications and services are built on top of SocialIntegrator, an API that we developed, using as a basis SocialAuth Core and Android Java Libraries [3]

1) Social Annotation Service (SAS): This RESTful web service supports the interactions between SC and AVC related components and takes care of all actions related to the social media (authorization, content posting and retrieval, etc), which remain transparent to the users of the applications. The SAS is responsible for automatically creating events in SNs and more explicitly in Facebook and Twitter and automatically upload representative movie photos to these events. To retrieve data of interest from target events hosted in SNs, the responsible sub-part, which is a daemon thread, monitors the related activity, having sufficient permissions and credentials of SNs' accounts, in a configurable time interval.

The SAS supports a variety of monitoring metrics regarding each representative photo in the social activity, such as the number of likes and comments for each photo, the comment with highest like count, i.e. top comment for given photo, the number of questions for each photo, the top question, the top answer for the top question, etc.

Using the aggregated information, the production team is assisted in understanding whether the audience and which age groups liked the movie and which specific parts. The "top question/comment" or photos' likes number could motivate organizers to revise the show, according to the popularity of particular topics.

2) Social Content Android Application - Student Application (SA): This Android application offers the students in the target audience a user-friendly way of interacting with teachers, experts and with each other via the SNs. The initial flow prompts the user to 'Sign In' via the supported SN of their choice and validate the appropriate permissions, passing

[3]https://code.google.com/p/socialauth/

on the ability to the application to take over permitted actions. The flow of the application is guided to the gallery, which contains the snapshots of the educational movie, as shown in Figure 2.

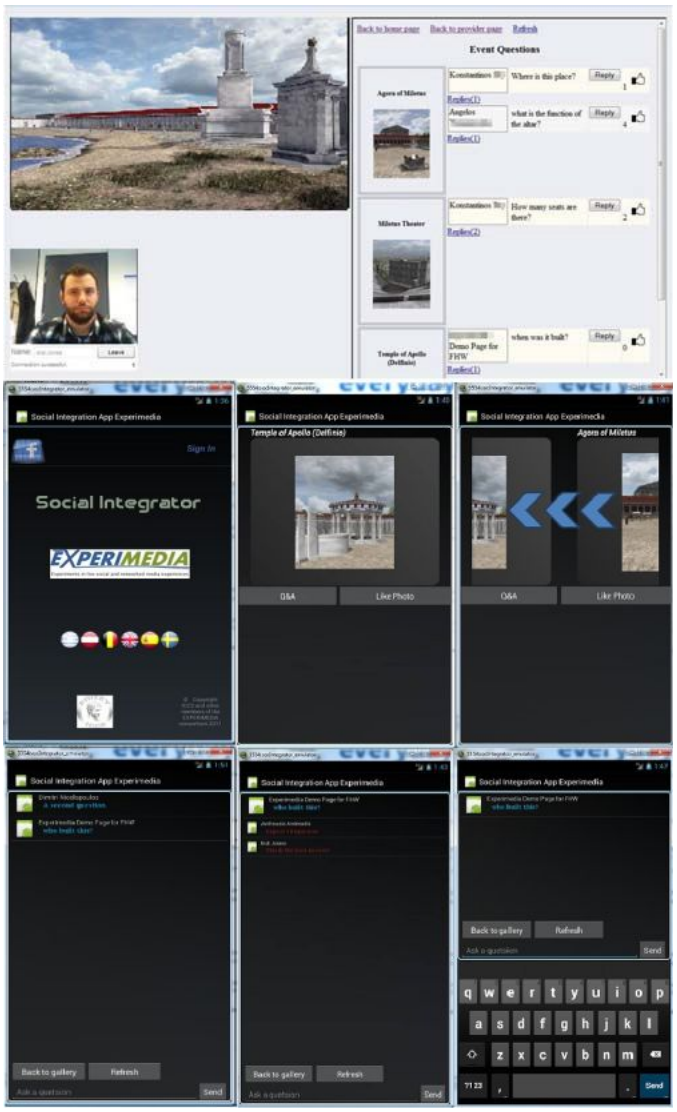

Figure 2. Top: Expert web-based application. Bottom: Student Application.

Furthermore this application enables location awareness possibilities, using the iBeacons technology, "a new class of low-powered, low-cost transmitters" that can notify nearby smart devices of their presence, taking advantage of Bluetooth Low Energy (BLE) technology. Using BLE, a device supporting iBeacons is able to both transmit a universally unique identifier and receive an iBeacon transmission. This way a better navigation in an educational venue is achieved, determining that a student is in front of a specific exhibit and triggering an action on his device which in our case is related to social media (check-in, content retrieval etc).

3) Expert Application (EA): The EA gives experts the ability to virtually attend the presented show by utilizing video streaming technology, allowing them to publish video and audio from their side. The real-time rendered content of Tholos is captured, multiplexed with the audio from the educator's microphone and streamed through external streaming servers to the web application.

The content of SNs appears on the right panel of the application. The experts are expected to login to both Facebook and Twitter and through this interface can see the photos of the event, their related comments, questions and answers. The experts can then choose to answer questions on which they have expertise, using the number of 'likes' of each question to choose the most popular questions, if they need to prioritize.

4) Educator Application: The Educator Application includes the video feeds of the remote experts and is equipped with a Flash object that sends their webcam and audio outputs to educator console in the Tholos. The content is streamed from the EA web interface to a media server, which relays the content to the educator console back in the Tholos, avoiding the need for the educational venue to have a complex firewall setting. Using this application, the educator can also invite the experts to talk to the audience, over the Tholos audio system.

B. Audio-visual content production and delivery

The Audio Visual Component (AVC) provides support to every part of the system, that requires multimedia content handling. The AVC consists of several modules, which work in a collaborative way to provide a set of services, including content acquisition from a media producer, adaptation and distribution of the content to different platforms, transcoding, streaming.

The AVC has implementations of three distinct image and video processing algorithms for Key Frame extraction (see Section V-C2), object detection based on HOG features [16] and a mean shift based object tracking [17].

V. The system in action

A. Integrating social networks in the Tholos experience

To integrate SNs with the students' real experience inside Tholos, we envisioned a concept of creating a virtual "event" on Facebook and Twitter for every educational show. In the case of Facebook, which supports the concept of events, this was straightforward and involved the creation of a Facebook event under the official Facebook page of FHW. As regards Twitter, which does not support events, we used "hashtags" for simulating an event and managing its content. Once the students login to their Facebook or Twitter account using their dedicated Android Application, they are automatically prompted to attend the specific Facebook or Twitter event respectively and thus have access to their feed, including comments, questions and answers.

Two issues arise here: correlating the questions with the appropriate part of the educational movie and grouping the questions under common referenced context for the experts (e.g. an architect might prefer to only view questions on historic buildings). The content projected on Tholos is rendered in real-time and depends on the selected course and navigation speed of the educator. Moreover, the fact that the students may type a question at their own pace regardless of the content displayed at that moment, as well as the latency introduced when posting/retrieving content to/from the SNs via the Internet, makes timestamp-based solutions inefficient in this case.

In our approach, with each new educational show, a list of photos of representative parts of the educational movie (e.g. historical sights) is added to the corresponding Facebook and Twitter events before the actual show begins. The SA retrieves dynamically these photos during the presentation, thus permitting the visitors to automatically associate questions or comments with the particular content of the movie. Meanwhile, the experts attend this social activity and answer to questions of their expertise, using their own dedicated EA. The definition of the content of photos and their creation was performed by FHW experts manually. However, this could be achieved in an automated way using video summarization techniques.

B. Achieving social network abstraction & privacy

One of the primary design attributes of SocialIntegrator is SN abstraction, i.e. providing the same functionality and user interface regardless of whether students or teachers log in to their Facebook or Twitter accounts. At the same time, the SN source of the feed should be abstract to the experts. This called for certain design and implementation decisions. In the case of Facebook, each photo has a unique message description. The implementation of audience's comments is connected to Facebook comments posted under the photo, when questions, which are not inherently supported per se, are implemented as separate posts on the feed by concatenating the photo's description with ':', and Facebook comments on those posts are the answers. With respect to Twitter, the event is identified by a short uncommon hashtag, such as #fhw_ev01, which should be present in every subsequent post related to the event. The photos uploaded by the FHW account should have, similar to Facebook, a unique hashtag, in addition to the event hashtag. Questions or comments on a photo are treated as tweets that have both photo's hashtags and an additional #q or #c hashtag respectively. A reply to a question in this case is simply a reply tweet to a question starting with event hashtag.

The usage of private events, which can only be seen by people who have received invitation and cannot be found in public search results, was essential for privacy or copyright reasons. Despite this, it was decided for the sake of privacy to use only Facebook when the system was deployed.

The users of the system can interact with each other and be part of this educational community, without providing personal information or adding friends to their contact/friend list. The design of the proposed system overcomes the problem of students becoming accustomed to a new practice, as in [1] with weblogs, since the majority of students is already familiar with the use of SNs.

C. Movie annotation using aggregated social information

In what follows, we present the part of the system that is responsible for collecting aggregated information from the social activity that takes place during the movie presentation and uses it to annotate the movie at real-time. We have chosen to use the MPEG-7 Standard and more particularly the AVCD profile [18] to provide a standardized way of capturing and storing this information. AVCD is a profile of the MPEG-7 scheme, originally proposed in [18], and more precisely a subset thereof, allowing for a faster implementation time as well as novel semantic interpretation of several entities. This profile has been used in several occasions in different contexts where humans are of interest in videos or other media.

1) Anthropocentric semantic information extraction based on MPEG-7: The basic idea behind the AVCD profile is to observe humans and their environment in video shots, and thus, organize the video content description according to human perception about a scene (thus the term Anthropocentric). Therefore, the AVCD profile introduces a structure where one can fill (manually, automatically, or semi-automatically) basic information that can subsequently be used in order to extract semantic information. The need for an MPEG-7 profile stems from the fact that plain MPEG-7 format is too abstract and cumbersome to be used efficiently under the scope of a specific target application as is in our case. We have concluded that the AVCD profile is a better suited to our purposes since the main goal is to have a structured metadata format that serves our application in a fast and seamless way. As an example of the use of the AVCD profile rather the MPEG-7 format as a whole, one can refer to Figure 3, where the differences between a typical MPEG-7 file with an MPEG-7 file profiled with the proposed structure, are illustrated. Both formats attempt to describe an object appearing in a shot. As can be seen, the use of intuitive notions such as object, object appearance, and object instance in the description make the format more simple and intuitive. Such notions are absent in the pure MPEG-7 description that uses still regions and moving regions as elementary descriptors.

Anthropocentric Descriptor

```
<ObjectAppearance id="OA001">
   <TimeIn>
      <MediaTimePoint>T00:00:00</MediaTimePoint>
  <\TimeIn>
  <TimeOut>
      <MediaTimePoint>T00:00:45</MediaTimePoint>
  <\TimeOut>
  <ObjectInstances>
     <ObjectInstance>......</ObjectInstance>
     <ObjectInstance>......</ObjectInstance>
     <ObjectInstance>......</ObjectInstance>
     <ObjectInstance>......</ObjectInstance>
  <\ObjectInstances>
```

MPEG-7 Descriptor

```
<MovingRegion id="SR01">
  <SpatioTemporalMask>
   <SubRegion>
    <FigureTrajectory type="1">
     <MediaTime>
       <MediaTimePoint>T00:00:00</MediaTimePoint>
       <MediaDuration>PT15S</MediaDuration>
     </MediaTime>
    </SubRegion>
   <SubRegion>
    <FigureTrajectory type="2">
     <MediaTime>
       <MediaTimePoint>T00:00:15</MediaTimePoint>
       <MediaDuration>PT30S</MediaDuration>
     </MediaTime>
     <Vertices>...</Vertices>
     <Vertices>...</Vertices>
     <Vertices>...</Vertices>
    </SubRegion>
   </SpatioTemporalMask>
</MovingRegion>
```

Figure 3. Left: typical MPEG-7 file, Right: MPEG-7 file profiled with the proposed structure

2) Event creation and automatic extraction of representative frames: Prior to the presentation of the educational movie, the production team uploads a 2D version of the movie into the AVC via its web GUI, and uses it to automatically create a dedicated event on the SNs. At the end of every process and upon success, the related information (Facebook event URL, uploaded photos) is stored in a PostgreSQL database and also returned to the AVC component for confirmation and future reference.

By clicking on the 'Add Event' link, the production team-creates an event for the specific movie and includes descriptive information such as the title of the movie, a short description, etc. Upon submission of this information, the AVC automatically triggers the SAS, which in turn creates a Facebook event for the given movie presentation.

Once the event is created, the production team can now specify objects of interest in the movie by clicking on the 'Add Object of Interest' link. The provided form allows for specifying descriptive information, such as an image, a video sequence or other predefined descriptors, which are used by the AVC in order to locate and track the objects of interest. At the end of this process, this information is stored in the AVCD format using instances of the class 'ObjectAppearance', as described in Section V-C1, and a representative frame for each object of interest is also automatically selected from the ones that have been detected and given appropriately IDs for subsequent queries in the AVCD xml file. For extracting the representative frame, we have defined a heuristic rule, which consists of selecting the one that includes the largest appearance of the object (i.e., the largest 2-D bounding box for the object of interest). This process can be repeated either multiple times or in parallel, depending on the objects of interest and the detection and tracking algorithms supported by the AVC. In our case we have used the first iterative method since the algorithms for detection and tracking used were based in simple one-object detection algorithms and simple one-object tracking ones. Regarding the efficiency of this key frame extraction strategy, the results collected during the experiments indicate that the extracted key frames are within a distance of less than 7 frames from the ones extracted with manual annotation and serve as ground truth.

Upon extraction of the representative frames, the latter become available in the AVC's web interface and at the same time, they are sent to the SAS, which in turn posts them to the dedicated Facebook event and become available to the students for posting comments, questions, answers related to each object of interest using the SA on their smartphones.

3) Real-time movie annotation using social data: While the movie is presented in Tholos and streamed to the remote Experts, different parts of the movie that have been uploaded in the AVC are automatically annotated with aggregated data collected by the SAS from the activity of the participants on the Facebook event, i.e. experts, students and teachers. The SAS runs a daemon thread that retrieves information from the Facebook event related to the representative video frames that have been uploaded previously for each object of interest, in a configurable time interval. The aggregated social information is then used to calculate useful metrics for each representative frame and send to the AVC component.

Once the annotation data have been received by the AVC, the latter locates the appearances of the objects of interest in the movie in the AVCD file using the unique identifiers of each representative frame that were created during the offline process, and includes the received data as attributes of the corresponding instance of 'ObjectAppearance'. A simple XML reader is used to query the AVCD file and return the annotation information that is stored within the file. Adequate visual queues (e.g., rectangles for bounding Boxes, colors for different objects etc.) are used to communicate the information stored within the AVCD file to the end-user through the AVC front-end at the time intervals that the object of interest appears in the movie. The aggregated feedback is being presented as annotation that is constantly updated during the viewing of the movie and the information displayed on the AVC front end can be disabled using a radio button(see Figure). The annotation data are seamlessly stored as metadata information, and thus can be exported and later on transferred along with the multimedia content.

Regarding the system's performance, as expected, the major delay of the system is related to the extraction and processing of the social information from the SNs. From conducted experiments against Facebook, the results indicate that the increase of the photos posted has an almost linear behaviour in terms of performance. However, the consumed time reaches a maximum of 106.45 msecs for 25 photos, which is an acceptable delay for a rather large number of photos. The number of comments per photo has a more negative impact on the cost since their processing involves sorting them according to their popularity. Still, the system behaves well for the most realistic cases, where the average number of comments related to each photo is below 10, reaching a maximum of 245.34 msecs for 30 comments per photo. Thus, the combination of very fast running times even in extreme cases makes the proposed annotation technique suitable for real-time movie annotation.

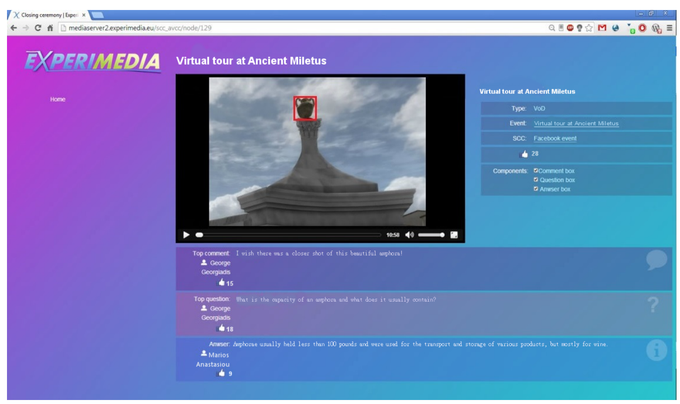

Figure 4. Object of interest tracked and annotated with aggregated data from SNs

D. Evaluation of the system by the end users

To evaluate the system in terms of enjoyment offered, but above all in terms of the value added for both the audience and the producers of the educational show, we have used questionnaires to collect feedback from both sides.

The response from the audience showed that 91% found it easy or very easy to use the application and 86% thought it was fun to use. The most important finding from the audience poll, though, lies in the fact that 82% of them stated that they learned more through this experience, than they would have by only watching the movie. The results from the producers' poll were very encouraging as well. More than 85% said that the feedback received in the form of aggregated social network activity was more useful than the feedback received by traditional methods, while 70% thought that the system might help the venue attract more visitors.

VI. Taking the application outside the Tholos Dome using Exhibition Beacons

The proposed system has also been deployed in the context of an additional real-life application, Exhibition Beacons (http://www.experimedia.eu/2014/10/10/blue-beacon/). This application introduces a new approach for tracking visitors at venues and has the potential to improve the experience of a school's students visit to a museum or an educational venue. During a school's visit the students, using the SA, can receive additional information on the specific exhibit in the form of multimedia content, see their classmates' questions and answers, post their own questions about a specific exhibit and receive instant answers from teachers or experts. The students can then decide to like, comment or share the information received on their own social media page, post their unique path in the venue, interact with each other improving their learning process, which becomes more personalized and provide valuable feedback to stakeholders.

Figure 5. Applying the system to Exhibition Beacons

VII. Conclusions

In this paper we described a system that introduces social media interaction and analysis and high quality multimedia content delivery to educational experiences in museums and cultural centers, allowing all involved stakeholders in the educational process to maximise the value extracted. Students, teachers and experts actively participate using specifically designed applications that allow them to become part of an educational community that emerges during this visit. Apart from offering a fresh, exciting experience on site, students also have access to the multimedia material presented at the educational venue annotated with data collected from SNs, which is created by their classmates, teachers and remote experts. This community remains active after the end of the visit to the venue, allowing its members to create and publish content, have access to further educational material and knowledge resources, interact with each other and share information, regardless of time and location. The proposed system has been deployed and tested at the Tholos Dome Theater of the Foundation of the Hellenic World, and the exciting comments received by students, teachers and all the professionals involved reveal the great opportunities that social media may offer towards a new approach to education.

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