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Original article

Audiovisual production, restoration-archiving and content management methods to preserve local tradition and folkloric heritage

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ABSTRACT

The current work focuses on the implementation of audiovisual production technologies for preservation and demonstration of local tradition and Cultural Heritage (CH). A methodological framework is proposed for the production, digitization, authoring and presentation of audiovisual (AV) content, related to traditional music and dances. The production chain involves content restoration, description and management of archived material, direction of documentary biographies, demonstration of folk customs and filming of chore-theatrical acts, aiming at creating historical, informative and educational video entities. User-friendly interactive environments are employed by means of media browsing menus and multilingual narration, utilizing new AV authoring. The proposed methodology has been implemented on the occasion of a folk-heritage multilingual DVD video production and its enhanced Web-TV edition[1]. The paper brings forward novel theoretical, technical and mostly methodological guidelines in preserving and disseminating CH, using state of the art AV production technologies.

1. Introduction

Nowadays, Information and Communication Technologies (ICT) are broadly used in CH projects. As examples, we may refer to web sites, virtual/e-museums and generally CH portals where archived documents are published, offering content management and dissemination services [1–5]. Among these, 3D-modeling is combined with virtual reality, 3D-interaction and navigation, augmenting user experience [6–12]. Besides web services, related ICT services are deployed for experiencing immersive virtual reality interaction while visiting real museums and other natural sites of CH [13].

Among the challenges and difficulties that have to be faced is the diversity of the CH expressions, along with the large-scale heterogeneity of the involved content, organizations and end-users[2]. A variety of different CH artifacts, documents and content types are involved (i.e. manuscripts, paintings, photos, films, tapes, vinyl records, sculptures, monuments, etc.) [1–5]. Content digitization and documentation is a common target of these quite dissimilar CH approaches, empowering digital replicas to express CH at a different level, and not as an inferior substitute of the original cultural expression-creation [2,6–8]. A very challenging task that state of the art technology is able to cope with is the preservation and exploitation of important audiovisual (AV) collections[3,4,5] [14,15].

In contrast to classical web elements (i.e. text and images), narrative AV documentaries are more easily attended, while being more informative and vivid at the same time. While 3D virtual reality and augmented interaction interfaces [6–13,16] enhance the provided information and functionality, they also create higher demands in computational load, bandwidth, powerful terminals and skilled users. In contrast to classical AV mass media, a somewhat drawback of these approaches is their lack to deliver massively the involved CH services to all possible social groups,

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[1] *"The clarinet in the Greek tradition: Vaios Maliaras, his life and work"*, online: http://arutv.ee.auth.gr/archiver/.

[2] http://ec.europa.eu/information_society/activities/digital_libraries/doc/refgroup/annexes/digiti_report.pdf (Report for the Comité des Sages of the European Commission, The Cost of Digitising Europe's *Cultural* Heritage, Nov. 2010).

[3] http://www.tape-online.net/docs/audiovisual_research_collections.pdf (Project report in the framework of the TAPE project on "Audiovisual research collections and their preservation", March 2008).

[4] http://tech.ebu.ch/docs/techreports/tr006.pdf (EBU technical report 006, June 2010).

[5] http://www.europeana.eu/portal (the largest European digital multimedia library, providing open access to several properly digitized and documented distributed collections).

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including technologically illiterate users and elderly people. AV production techniques tend to overcome the above difficulties, incorporating multimodal documentaries and contemporary Interactive TV (ITV) services, using less complicated front-ends. Easier distribution of high quality AV content is also feasible, taking advantage of new media (Web-TV, mobile-TV, etc.) that have great infiltration to most social groups, while intellectual property management and content protection issues can be settled [15,17–22].

2. Research aims

Naturally, AV-CH projects are more conveniently deployed in cases that inherently belong to the AV industry, like the folk music and dances' heritage. In such cases, it is helpful to utilize historical AV documents related to artists, folkloric legends, cultural customs and local tradition, which can be combined with newly produced media assets, aiming at offering rich-media experience. This creates further necessities compared to standard AV production, requiring special treatment that the current paper focuses on, presenting an integrated methodology on *Cultural Heritage Audiovisual Documentation-Dissemination* (CH-ADD). The proposed methodology includes:

- implementation of AV digitization and processing for the needs of content restoration and documentation;
- direction and shooting of new AV production entities (e.g. logographic interviews, journalism essays, choreographies, chore-theatrical drama, etc.);
- implementation of applicable description schemes for efficient management of both archived and newly produced content;
- AV authoring and release of rich-media CH services, taking advantage of novel broadcasting technologies, featuring high quality, easy operation and enhanced user interaction.

The proposed models encompass interdisciplinary collaboration between experts of various fields for efficiently conducting CH projects.

3. Cultural Heritage Audiovisual Documentation-Dissemination

As already mentioned, the proposed methodology has been implemented on the occasion of the DVD video production *The clarinet in the Greek tradition: Vaios Maliaras, his life and work*[1], demonstrating various folkloric aspects of the wider region of Thessaly, Greece. In such a project, proper AV content processing and archiving are essential, requiring sophisticated documentation and management [17]. To address the challenges involved in the process, a modular desktop application was implemented in LabVIEW[6], taking advantage of its Graphical User Interfacing (GUI) and the already implemented AV processing and content management tools [23–26]. The application was positively evaluated for its usefulness at the production site, despite its integration and distribution limitations (i.e. not fully integrated with the remaining AV production environments, related meta-data had to be manually inserted). Methodology updates were drawn for the release of an enhanced Web-TV edition, seeking for online distribution and AV-CH dissemination enhancement. ARUTV[7] was selected as deployment platform, due to the advanced content description, browsing and retrieval capabilities supported. Gradual refactoring of web-based management and AV authoring was decided, aiming at augmenting automation, networked collaboration, end-users' contribution and interaction. Based on this experience, technical information and methodological aspects are presented, without providing technical details over software engineering and AV processing algorithms.

4. Material and methods

Besides the basic requirements that are common in most film-TV productions [15,17,21], the current work has certain specificities that are related to the very distinct nature of CH tasks. Hence, for historical, aesthetic and creative reasons, archived material should be as much as possible employed, since it inherently exhibits originality. This has a great influence on production scripting and organization, which have to be accommodated on the availability of archived AV material. Besides, a main task of CH is the preservation and documentation of this historical-cultural material. While processing is necessary for the restoration and adaptation of the Digitally Archived (DA) AV material, new Digitally Created (DC) content is engaged aiming at providing new digital story-telling contexts. A block diagram representing the relationships between material, methods and services is provided in Fig. 1.

4.1. Digitization, restoration and documentation of archived audiovisual material

The first task in AV-CH is content digitization and documentation. Hardware equipment is necessary for Analog to Digital Conversion (ADC) of the archived AV material, whereas availability of proper well-operating playback devices is crucial (e.g. u-matic and filmed video, vinyl records pick-up playback devices, etc.). Analog signal processing or even storage-medium based treatment might be applied for content restoration-enhancement, prior to the digitization process [27,28]. Format selection and digitization parameters need to be decided from the early beginning of the project, determining content-quality along with the applicable publishing-broadcasting formats. The adopted-strategy suggests attainment of maximum available and affordable quality during ADC, even if lower quality is used in the project, whereas lossless compression can be also utilized. While this settlement favors enhanced future releases and re-publishing, much care should be taken for avoiding unreasonable digitization-compression and wasting storage capacity, with the risk to create additional artifacts.

Referring to Figs. 1 and 2, DA High Quality Reference Content (HQRC) is used as master reference that allows the creation and extraction of lower quality content profiles. Hence, needless transcoding/up-scaling that would lead to unwanted loss of information and quality degradation are avoided. In case that the project's quality specifications are lower than the HQRC profile, transcoding might be needed for the extraction of the Initial Project Oriented Content (IPOC). For safety reasons, both HQRC and IPOC reference content should be properly preserved-duplicated. Based on the preceding analysis, it is quite difficult to encode archived AV material in acceptable quality in the new digital high definition (HD) formats. This deteriorates the possibility of taking full advantage of contemporary high quality HD production technologies. Fortunately, filmed AV material inherently offers higher resolution than standard TV, while reasonable up-scaling is also feasible [21]. Another useful technique is the use of lower resolution pictures and video-frames, in combination with picture-in-picture views and other motion effects, resulting in animated photo-stories (APS) [17]. In this context, low-resolution material can be used in higher definition CH productions, whereas text-over, graphical layers, and animations can be inserted to fill out the scene area gaps.

[6] www.ni.com.
[7] http://arutv.ee.auth.gr (*ARUTV: "are you TV"* - Aristotle University Web-TV platform).

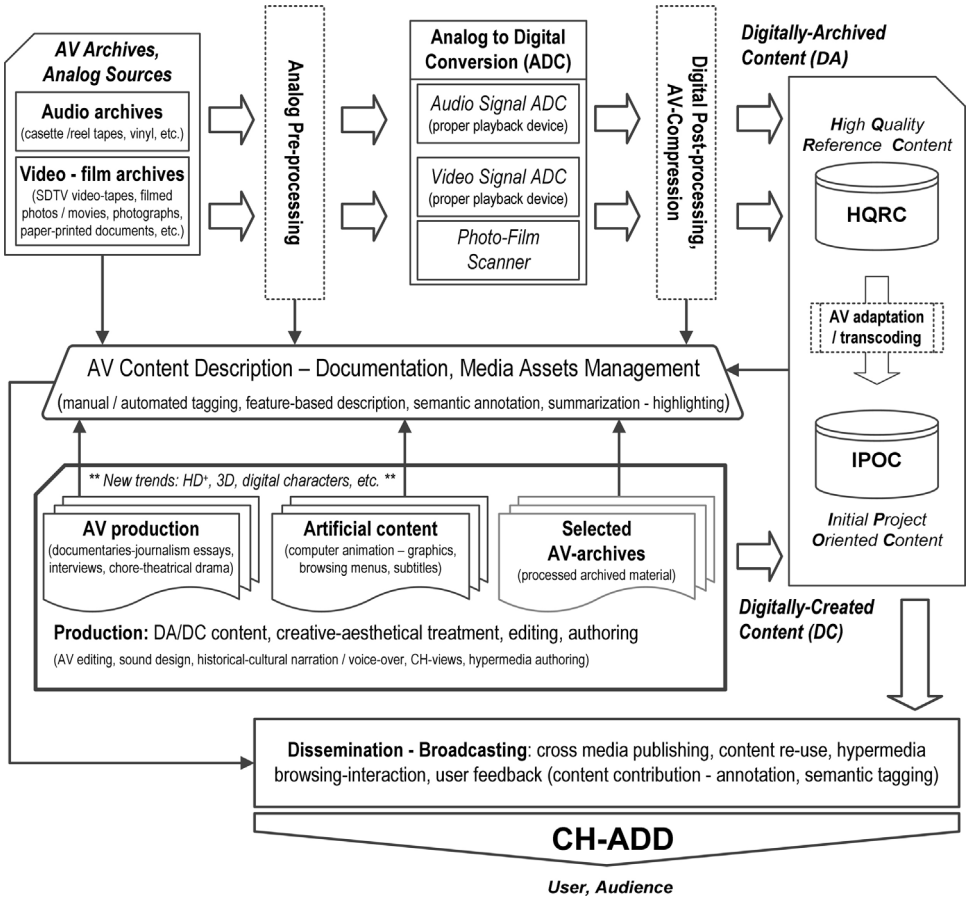

Fig. 1. Block diagram of the proposed Cultural Heritage Audiovisual Documentation-Dissemination (CH-ADD) methodology.

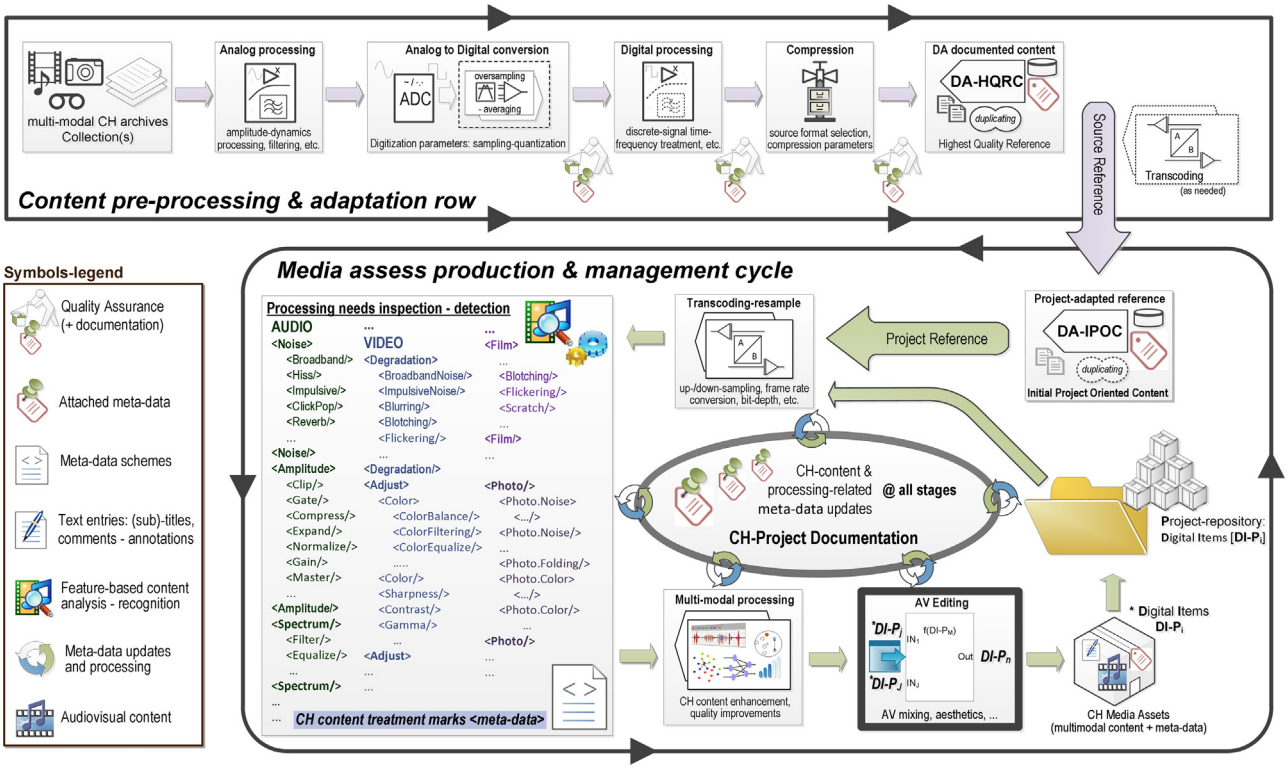

Fig. 2. Layout of the archived AV material restoration, digitization and documentation process.

AV archives of old-analog recordings suffer from various quality degradation issues. Common noising problems at various media and content types can be found in related bibliography [23,25,29–31] and they are also listed in Fig. 2 (along with general AV processing needs). According to Fig. 2, the proposed CHA-AD methodology employs two separate-successive processes for AV content restoration. In particular, besides the enhancement process itself, there is a preceding inspection phase that detects noise contamination issues, pointing out processing needs for quality improvements. This separation offers autonomy and allows the two systems to be elaborated in parallel, aiming at achieving maximum performance with the use of manual, semi-supervised and fully automated procedures.

Audiotapes and vinyl records, which are dominant in folk music CH, suffer from additive broadband noise, hiss and lots of clicks. Perceptually adapted Wavelet Domain Wiener Filtering (WDWF) [23] was proved to be a good choice for audio content restoration, where new configuration adaptations were made to face the current project demands. Following the $WDWF_{1l\text{-}17}$[8] scheme, 37-bands[9] were formed in the range 0–22050 Hz (44.1 kHz sampling rate). Noise footprint is still manually indicated at the beginning of each track, while adaptation is employed using smooth exponential averaging of the extracted noise components. The new hybrid $WDWF_{H\text{-}37}$ module was further elaborated by iteratively processing the de-noised components with lighter thresholds. The last accommodation was made in order to further eliminate unwanted de-noising artifacts, which are very annoying and incongruous to the initial content nature. This matter is very important in CH projects, where it is preferable even to leave out small noise components, as long as they do not seriously affect audiovisual perception, since they pose originality.

$WDWF_{H\text{-}37}$ was proved very efficient, having superior performance from most of the commercially available de-noising tools. Except for the elimination of de-noising artifacts, another advantage is the simultaneous smooth suppression of unwanted clicks. Motivated from spatial audio enhancement techniques [32], conjoint stereo peak compression allowed further suppressing of clicks and pops, but also clipping restoration. $WDWF_{H\text{-}37}$ de-noising was also employed for the remaining speech and generally AV archives used in the project, while further amplitude and spectral processing was carried out as needed in common DAWs[10], along with the remaining editing-mixing necessities.

Archived visual content also requires restoration treatment [21,29,30]. The effort was concentrated on the enhancement of the digitized content, and not before or during the ADC process like other works do [21,27,28]. Most of the work involved the treatment of scanned photos, but also films and videotapes. Wavelet Domain Empirical Wiener Filtering (WD-EWF) was followed as in [25], but with some basic configuration updates. Hence, order filtering is firstly applied, estimating noise footprint, which is then used as input in 2D-WDWF restoration (extending the 1D-WDWF previously presented in two dimensions). These modifications were also adopted in the JWVD-MAD[11] video enhancement algorithm, along with WT-D-BRFR[12] motion detection improvements. Specifically, motion activity curves are now estimated for each wavelet scale, increasing adaptability and motion detection accuracy in a per-scale basis, while global-motion is extracted by integrating sub-motion-images.

The above tools were successfully utilized for common image-video enhancement of the visual CH content (e.g. removal of additive broadband noise, salt and pepper spots, grain, blotching, etc.). Further processing was on demand deployed in related editing-authoring environments during the corresponding production phases, along with common creative-aesthetic treatment (e.g. removal-concealment of paper-folds and scratches, color adjustment, contrast-scaling effects, etc.). In methodological terms, despite the choices that were made in the current project, there is a plurality of applicable noise recognition and AV content enhancement algorithms [21,23–25,29–32] that may be deployed. Thus, the methodology models of Figs. 1 and 2 outclass the particularities of the specific work, and can be deployed in more generic AV-CH scenarios.

Following content restoration-archiving, proper content documentation is essential in the AV production industry and especially in CH projects. Based on previous experience and related state of research, specific media management technologies were investigated for their data-structures and delivery mechanism [2,7,14,15,22,33,34]. Among these, Dublin Core and MPEG-7 were examined for applicable description schemes and low-level descriptors, while MXF[13] (that is preferred by experienced broadcasters[4]) and MPEG-21 were explored as solutions that bundle together media assets (both AV content and meta-data), serving interoperability and transparent multimedia access.

According to Fig. 1, both content and content-treatment-related meta-information is involved in the CH-ADD methodology. Following MPEG-21 terminology, CH-ADD is composed of digital items (DIs), representing various content instances along with their meta-data that describe their origin, processing and editing throughout their entire life-cycle (Fig. 2). The proposed content description ontology incorporates most of the features that are common in the previously mentioned protocols (Fig. 3). This allows for descriptions, compatible with these standards, to be extracted, serving interoperability. Specifically, textual information is used for the general *who*, *what*, *where* and *when* descriptions, while internal AV segmentation-description is implemented for the time-based media (TBM).

A media playback, annotation and visualization environment was implemented in LabVIEW, incorporating AV feature-engines support. Following earlier implementations [24,25], a GUI was adapted to serve the CH-ADD annotation demands (Fig. 3). All meta-data (textual entries, segmentation-timing and AV feature values) are stored in separated indexing files following the "bits about the bits" MPEG-7 philosophy. LabVIEW's datalog technology was adopted, storing the meta-information as cluster records in binary files. In this context, each of the involved DIs is consisted of the source media and the separate dlog-file that is created during the description process, using the applicable fields in each media type. Project summarization is supported by listing all active DIs in a master dlog-file, speeding-up meta-data accessing-processing. Within this settlement, fast and easy meta-data processing is offered without the need of a database support. The advantages of the above solution over other media annotation and media assets management tools are related to the implemented GUI that is adapted to CH-ADD and is easily operated from ordinary users (at the production site), and most of all the underlying AV feature-engines. Extraction to schema-defined XML files is also available, offering interoperability with other standards and other annotation

[8] Wavelet Packet Analysis (WPA)-based WDWF: it uses 17 spectral bins approximating bark-scale spacing [23].

[9] Having frequency bandwidth of 86 Hz (the first 12), 172 Hz (4), 344 Hz (9), 688 Hz (5), 1376 Hz (4) and 2752 Hz [3].

[10] Digital Audio Workstations.

[11] Joint Wavelet Video De-noising Motion Activity Detection [25].

[12] Wavelet Transform -based Dynamic Background Foreground Segmentation [25].

[13] Material Exchange Format.

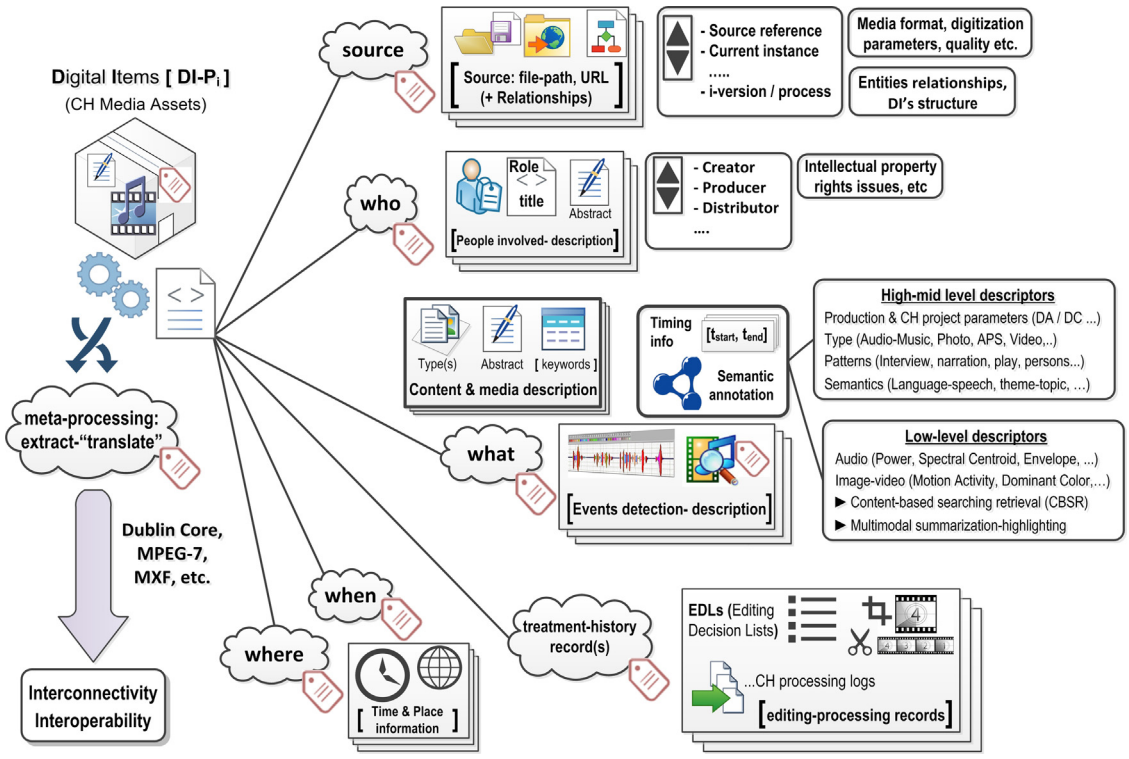

Fig. 3. The proposed ontology for content documentation, description and management.

environments (i.e ELAN[14], SonicVisualizer[15], etc.) that are preferred from experienced users. This option has been adopted during the web-refactoring process in ARUTV, further extended by MySQL database support.

Considering the internal segmentation process, the updated WT-D-BRFR algorithm was used for the visual TBM. Specifically, global motion curves are used to decide detection boundaries, serving also summarization and content-based searching-retrieval (CBSR), along with motion activity and dominant color low-level descriptors of each segment. A thumbnail is extracted from the first frame of every segment, along with a binary motion image (where maximum motion occurs [25]), serving summarization and highlighting. LT-WDSS[16] algorithm was updated to serve CH-audio segmentation via multiband level-comparisons. Specifically, 9 log-scale bands were formed in the range 0–22050 Hz (44.1 kHz sampling rate). Threshold updating was introduced using the WT-D-BRFR iterative exponential averaging [25], where foreground-background images are interchanged with signal-noise levels, both in the coarse and fine detection processes. Point-to-point audio-power-level estimation is used in the fine-tuning process, instead of short-block fractal dimension. This configuration was successfully utilized for the segmentation of restored DA and DC audio. Audio-power and spectrum-envelope, extracted in the LT-WDSS process, serve audio visualization and summarization, while spectral centroid is additionally used for CBSR.

Multimodal segmentation is conducted in AV content, utilizing both audio and video methods [25,26]. Feature visualization and clustering facilitate AV pattern-classification, serving high and mid-level semantics. In methodological terms, a variety of AV features, alternative classification schemes and recognition techniques can be employed, as Fig. 3 implies. Supervised treatment was preferred over fully automated methods in all the processes, offering increased accuracy and control. Nevertheless, a gradually expanding ground-truth knowledge base has been established for both restoration and recognition tasks, and it can be used for the training of fully automated intelligent systems.

4.2. Production of new content: chore-theatrical plays and documentaries

Besides DA content, audiovisual shooting is employed for the creation of new DC media, satisfying different aspects of the production demands. Reenactment of chore-theatrical plays, interviews and representation of traditional-folk customs are ideal for the preparation of historical-cultural journalism essays and educational documentaries on various aspects of CH. Careful production setup in dedicated native places is essential for avoiding capturing annoying images and/or sounds of modern civilization. Ambient environmental sounds are useful in the sound design process, while "neutral frames" (cultural environments buildings, natural landscapes, monuments, etc.) can be utilized as video inserts. Both outdoor and studio recordings are involved, where close-miking and multi-camera shooting techniques are engaged [15,17,21].

The post-production phase incorporates all the AV processing and editing tasks, so that both DA- and DC-AV entities will be supplemented with additional content towards the final composition (Figs. 1 and 2). Technical errors, omissions and other problems that have been created during the preceding production phases can be settled here (e.g. creative treatment is very likely to mask noise problems and/or processing artifacts). Narrative multilingual audio, subtitling and graphics are useful for aesthetic and informative reasons, allowing to rush the pace of the action and to affect the whole aesthetics of the movie. Sound effects are inserted in order to match with what is viewed on screen, but also with ambient sound and sound sources that are not seen. Background music shapes the atmosphere, adds emotion and rhythm to the movie, but it also may have a diegetic nature, presenting actual sounds

[14] http://tla.mpi.nl/tools/tla-tools/elan/.
[15] www.sonicvisualiser.org/.
[16] Long Term Wavelet-based Detection Segmentation and Summarization [24]

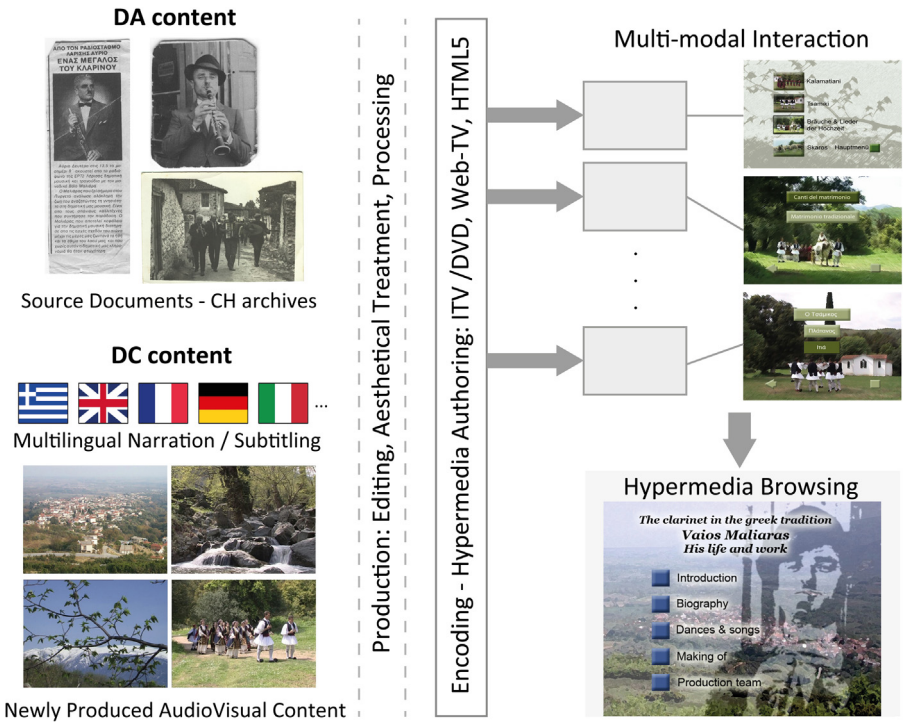

Fig. 4. Typical content organization structures with accompanying navigation menus.

that were originated in the film word, either their source is visible or not.

Content documentation applies for all the produced DC entities as Figs. 1–3 imply, facilitating content synchronization-alignment and generally AV editing-authoring. Ideally, processing logs and edit decision lists (EDL) can be automatically documented in case that the content management system is fully integrated with the AV editing and authoring modules (Fig. 3); manual description inserts are required otherwise. Towards this direction, a collection of web-based AV editing tools provided through the ARUTV platform was tested. Automatic extraction of semantic information is delivered during the content creation/editing process, by analyzing user actions captured in EDL-like logs along with their relation to lower level AV features. Hence, valuable information that is involved in the editing process can be exploited, without the need of by-hand annotations. The implemented prototypes were tested in trial and error scenarios using limited multi-track AV editing capabilities (i.e. cuts, fades, cross fades, alpha transparency, etc.). Communication with the main CH-ADD annotation environment was established tHrough XML files exchange, pre-registering

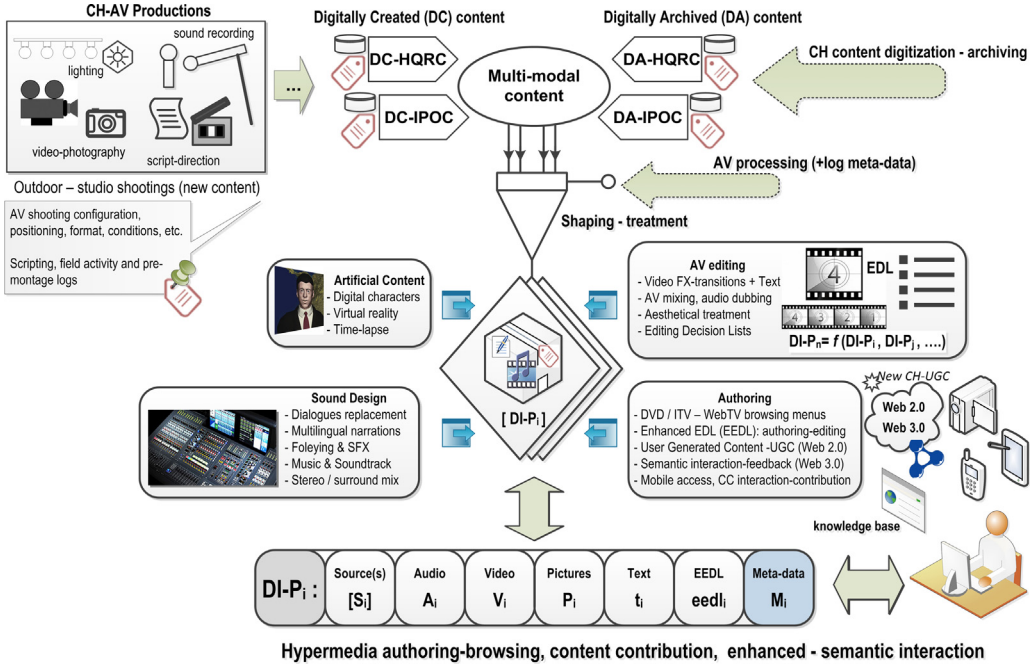

Fig. 5. End-to-end flow diagram of the proposed CH-ADD model, including enhanced user semantic interaction and contribution in terms of Web 2.0/3.0 CH services.

internal segmentation tags with EDL-adapted comments. While alternative, more sophisticated communication solutions exist, the aim is focused in refactoring the CH-ADD annotation platform into the web, along with full deployment of additional editing capabilities. Thus, web-based remotely collaborative editing can be deployed, allowing experts and ordinary end-users to be involved in the process, while offering management automation facilities.

4.3. Hypermedia authoring and interactive services

The implementation of dialogic modes aims at further stimulating the human experience, arousing users' interests to actively participate in such interactive scenarios. Interactive DVD video-titles entice users to explore all the available navigation, which is very important in CH projects [17,20]. In contrast to computer-based applications, these interactive services can be deployed via Web-TV/ITV programs, taking advantage of contemporary web-ready TV sets. Thus, they address nearly all potential users, including elderly people that are more interested in CH and folk-heritage projects. Computerized hypermedia approaches are also available [19], augmenting user interaction and allowing full exploitation of recent ICT capabilities and Web 2.0/3.0 trends.

AV-CH hypermedia can be organized into different levels according to the provided CH information, the used content types, the involved languages, the presentation of the project's identity and its preparation phases. In the involved project, both DA and DC content is utilized in the multilingual AV browsing graphical menus (Fig. 4), offering the ability to switch between five different languages (Greek, English, French, German and Italian) [17]. As already mentioned, the implementation of a related Web-TV edition was decided aiming at online distribution with better dissemination results, whereas two different approaches were followed:

- automated transformation of standard DVD releases into web distributable multimedia;
- re-authoring capabilities using existing DVD-objects and/or additional-source material, as it is presented in Fig. 4 by replacing specific content-interaction entities.

Specifically, to be able to demonstrate the described functionality, and since none of the existing solutions provided such utilities, a new tool was developed. A set of server side executed scripts was utilized for the encoding and reproduction of the source content into a web-compatible hypermedia format. Certain tools (i.e. *MENCODER*, *FFMPEG* and *DGMPGDEc*) are employed for the *h264* and *mp3* encoding of video and audio streams, respectively, which are eventually bundled in an mp4 file-container. DVD-menu reproduction is generated implementing *HTML5* scripting, along with *javascript* and *AJAX* client-side web-technologies. Content playback is handled by *flowplayer* on the client-side, while *PHP* pseudostreaming is implemented on the server side.

Fig. 5 provides an end-to-end flow diagram that the proposed CH-ADD architecture can support, including user generated content (UGC) Web 2.0 models. The notion of Enhanced Edit Decision Lists (EEDL) is introduced to model authoring and enhanced hypermedia services, favoring remote collaboration of both experts and regular users. This is very important considering that the majority of local tradition and folkloric heritage documents (photos, AV documents, etc.) is usually kept unpublished in personal collections[3] [17]. Hence, user contribution is essential in further preserving and disseminating CH, while semantic interaction is vital for future automation by implementing intelligent CH agents and related Web 3.0 services. From the user point of view, semantic feedback facilitates user-customization/personalization, though context-location aware mobile services and cloud computing (CC) hypermedia can be offered while attending a folkloric festival, a folk museum or a cultural event in general.

5. Results and conclusion

The current paper focuses on audiovisual CH documentation and dissemination, with emphasis on local tradition and folkloric heritage. Motivated from an earlier DVD video CH production, an integrated methodology is proposed for AV digitization, restoration-archiving, content dissemination and management. The proposed CH-ADD methodology models intelligent CH management, along with enhanced hypermedia interaction and cross media publishing capabilities. Based on this, rich-media updates can be easily delivered for the involved *Vaios Maliaras* project[1], envisioning its continuous evolution, dissemination and maintenance (e.g. gathering of additional photo-collections and AV documents, incorporation of further languages, expansion of the offered hypermedia services, etc.).

The current paper brings forward scientific, technological, creative and mostly methodological aspects that can be successfully employed in a variety of CH projects. Exploitation of state of the art Web 2.0/3.0 CH services are among the innovative aspects of the proposed methodology, facilitating enhanced user-participation in terms of content contribution, collaborative management, augmented semantic interaction and hypermedia authoring. As a consequence, public-awareness and active involvement of ordinary people-users into demanding CH actions is pursued, expediting related projects' dissemination but also providing valuable feedback for future directions of CH.

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