Signal Processing 90 (2010) 1077–1082

Contents lists available at ScienceDirect

Signal Processing

journal homepage: www.elsevier.com/locate/sigpro

Structuring and navigating ethnic music archives

Antonina Dattolo

Department of Mathematics and Computer Science, University of Udine via delle Scienze, 206 I-33100 Udine, Italy

ARTICLE INFO

Article history:
Received 30 November 2008
Received in revised form
4 May 2009
Accepted 21 August 2009
Available online 3 September 2009

Keywords:
Hypermedia structures
Web 2.0
Navigation
Authoring
Multi-agents models

ABSTRACT

Web 2.0 represents a new challenge for the ethno-musicology and outlines new modalities of storing and structuring music archives, counting on the active participation and interaction of users that become authors and can directly create, express themselves and communicate.

This paper proposes a distributed framework, based on a multi-agent approach, aimed at aggregating ethno-music communities for sharing existing archives and other data, creating new knowledge and improving the access.

1. Introduction

In the last ten years, meaningful advances in the development of audio technology (24 bit analogue/digital converters, sampler at 192 kHz, optical carriers-Blu-ray disc- with 54 GB and magnetic tape storage, e.g. LTO-4, with 800 GB) and an active experimentation with integrated multimedia systems (using both audio and video signals) offered new possibilities for the treatment of audio/video documents. From a technical point of view, it became possible to enable users to store, navigate and compare several sound sources at different representation levels, such as the data needed for the performance (as scores or oral instructions), the video shooting of the artistic event and the meta data (as annotations or signs on the carrier).

In these same years, the Web consolidated its success and it is proposing a great revolution in the way of sharing and accessing information [1]: there is growing evidence of two parallel worlds, the traditional world constituted by the mostly read-only Web, and the new Web 2.0-based world, in which each user may become author and share his/her documents with a world wide community [2]. Key concepts of Web 2.0 are knowledge sharing, mass collaboration, collective intelligence and User-Generated Content (UGC).

In this innovative context, the ethno-musicology finds it difficult to move with the times: actually, numerous, disseminated private collections and some public and institutional archives compose ethnic-musical heritage and the ethno-music communities do not own tools adequate to sharing existing (or new resources), or to improve the diffusion and access.

The majority of works regarding the application of technology in this field are related to computer-aided research finalized to problems as segmentation and alignment of music [3], evaluation of music similarity, scale-perception or analysis of melodic surface structure [4]. Very few works have been dedicated to the access and authoring of contents [5], although the exigency of innovation is emphasized in many works [6] and talks [7], in which the concept of virtual music community is indicated as the second revolutionary trend within a new, emerging field for the scholarly inquiry.

Contribute of this work. The contribute of this work is the proposal of a groundbreaking way to structure and visualize music archives; it proposes a distributed frame-

E-mail address: antonina.dattolo@uniud.it

0165-1684/$ - see front matter © 2009 Elsevier B.V. All rights reserved.
doi:10.1016/j.sigpro.2009.08.009

work, based on a multi-agent approach, aimed at aggregating ethno-music communities for sharing existing archives and other data, creating new knowledge and improving the access.

Potential users are scholars, musicologists, expert of ethno-musicology, owners of private documents or archives, public institutions or, simply, people interested to share data and knowledge within an ethno-music community. The framework uses innovative data structures, called zz-structures [8]; it is part of a more complex project for the fruition of multidimensional documents [5,9]. Each user becomes author: he/she can add new information and documents, introduce specific tags for them, semantically connect them, retrieve them, sharing all (or parts) of them with all (or selected) members of the new virtual community, create social relationships with other people.

Case study. The context of case study are typical rites of Sicilian folk culture [10], such as the *ladate dei fogghiamari* (chants of the pickers of bitter vegetables) of Caltanissetta and *Strepiti dei Giudei* (cries of the Jews) of San Fratello.

The *ladate dei fogghiamari* has a lamentable intonation: it has something of the Arab lament, of the liturgical Byzantine chant and the Gregorian chant of the lamentations of the prophet Jeremiah. The leading actors of the the *Strepiti dei Giudei* are the village men folk, who freely roam the streets playing loudly and menacingly as they swing a thick chain known as *d'scplina*. The trumpets, as the instruments used are generically named, are the main element in the Jews' costumes, whereas they are actually both trumpets and cornets, with or without a tuning slide.

The *Strepiti dei Giudei* of San Fratello are also known as *Terremoto* (Earthquake) or *Tremmete* (Tremor) or *Bbatte porte* (Bang the doors): they imitate the cries and the havoc that erupted during the seizing of Christ by the soldiers (the Jews).

Outline. This paper is organized as follows: Section 2 presents the general architecture of the distributed framework; Section 3 discusses the organization of Knowledge Base, the dynamic updates on it and an example of interaction between the user and the system; Section 4 focuses on navigation and the visualization of dynamic views. Conclusions end the work.

2. The framework

The ethnic music is a part of culture and social life; for this motive, it is necessary to take trace and manage a wide set of information (not only the audio documents): for example, the social event in which the music was performed, the dancers, the musicians, the musical instruments, the recording equipment and the scores.

The architecture of our framework contains three layers, as shown in Fig. 1.

The *Storage Layer* strongly connects two bases: in the Information Base, users store different media, such as text, static images, audio signals, videos, musical transcriptions, audio analysis, etc.; the Knowledge Base organizes the data contained in the Information Base, defining appropriate data structures in order to facilitate accessing and information retrieving of documents.

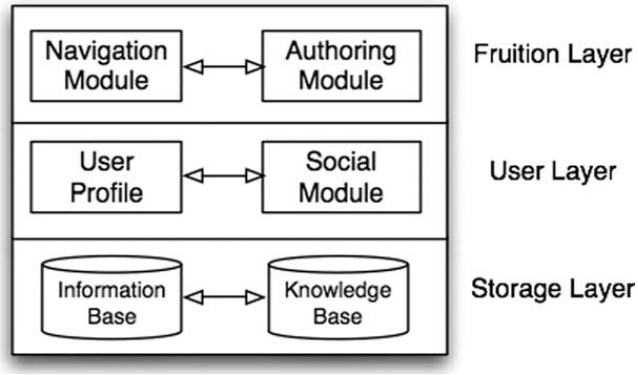

Fig. 1. The distributed framework.

The *User Layer* is composed by the User Profile module, that records the personal history of the user interaction with the system, his/her preferences, the list of used tags and stored documents and his/her concept maps; and the Social Module, that manages the social network.

The *Fruition Layer* is composed by the Navigation Module, that enables users in navigating the Knowledge Base, proposing graph-based views of it, on social networks and on user concept maps; and, the Authoring Module, that implements the features users can invoke to add new multi-dimensional documents, tag and connect them in opportune structure.

3. Knowledge Base and authoring

Let us suppose that a user uploads a set of documents, related to the *ladate dei fogghiamari*, as shown in Fig. 2.

The documents may be, for example, scores, audio signals represented in time or frequency domains, photos, videos, transcriptions of different typologies, texts. Also, let us suppose the user tags each document, using shared or personal keywords: examples of tags could be the name of the event (fogghiamari), the typology of ritual (liturgical), the city of the event (caltanisetta), the features of music (melodic, harmonic), and so on. These data, stored in the Information Base, are managed by the Knowledge Base and organized in zz-structures.

3.1. zz-structures

Zz-structures represent a new, graph-centric system of conventions for data and computing presented in [8,11–13]; they generalize lists, two-dimensional arrays and trees, and, encoding multiple alternative sub-structures, they also subsume polyarchies and mSpaces. In particular, in our specific application field, zz-structures are adequate for supporting the multiplicity and variety of relations among the data and the need to carry out searches on attributes, and to introduce new objects and new runtime relations.

Zz-structures are based on the non-Euclidean multi-dimensional model [8]; a formal description, based on

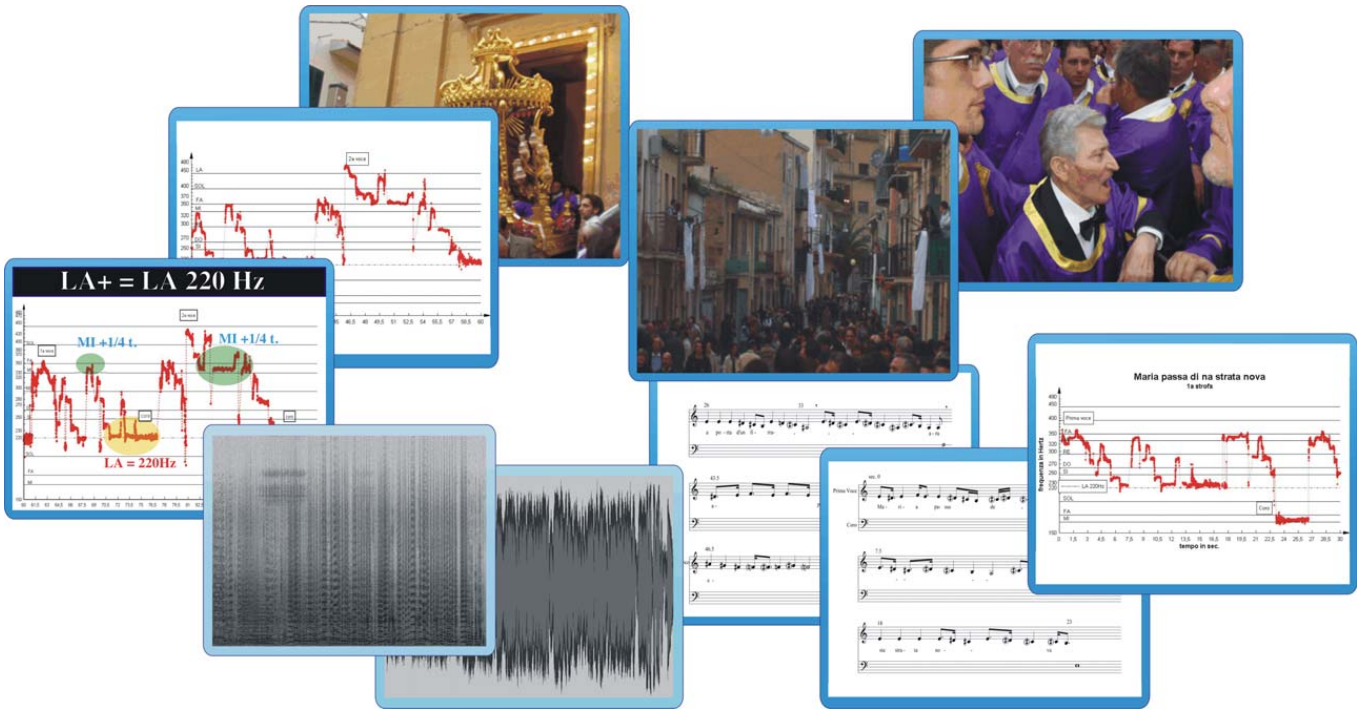

Fig. 2. A set of documents related to the *ladate dei fogghiamari*.

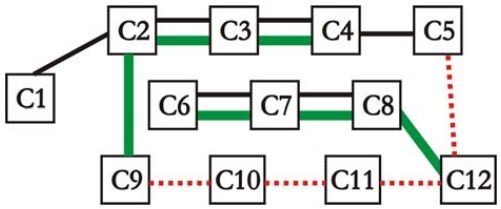

Fig. 3. An example of zz-structure.

graph theory and multi-agent paradigm, is presented in Ref. [11].

A zz-structure can be thought of as a space filled with cells. Each cell may have a content (such as integers, text, images, audio, etc.). Cells are connected together with links of the same colour into linear sequences called *dimensions*. A single series of cells connected in the same dimension is called rank, i.e., a rank is in a particular dimension. Moreover, a dimension may contain many parallel *ranks*. A fundamental restriction is that for any dimension, a cell can only have one connection in input, and one in output; this ensures that all paths are non-branching, and thus embodies the simplest possible mechanism for traversing links. An example of zz-structure is shown in Fig. 3.

This zz-structure is composed by 12 cells, {C1, …, C12}, connected by three different dimensions, denoted respectively by thick, normal and dotted lines.

In Fig. 4, the same zz-structure of Fig. 3 has been decomposed in its dimensions, and related ranks.

In particular, the thick dimension contains two parallel ranks {(C9, C2, C3, C4), (C6, C7, C8)} and five isolated cells {C1, C5, C10, C11, C12}, the normal dimension two parallel ranks and four isolated cells, while the dotted dimension one rank seven isolated cells.

3.2. Populating the Knowledge Base

Each time a user uploads a new multi-dimensional document and tags it, this information is added by a specific class of agents in the Information Base and automatically loaded and processed in the Knowledge Base: the document will represent a new cell, while each tag will be associated to a dimension, if already it has been used, and will connect the new document with the others (tagged with the same tag). If the tag is new, a new dimension will be created, containing the only added document.

The grouping of documents in parallel ranks of a same dimension is generated by specialized queries. For example, a dimension may be named *fogghiamari*, and a specialization of this dimension may be the year in which the event happened (2008, 2007, and so on).

Another interesting example is the organization of the set of copies, versions or variants, originated by the same analogical document (such as the new versions generated, for example, by a re-mastering process, or by specific restorations). In this situation, a user can annotate the different copies, using parallel ranks of same dimensions: the information is so structured in knowledge, and management, comparison and retrieval processes related to different digital copies are simplified.

Users can choose to manually create new ranks and dimensions, specifying the set of documents and a common tag. Several ordering of cells coexist in a natural way; the introduction of new tags (=dimension) enriches

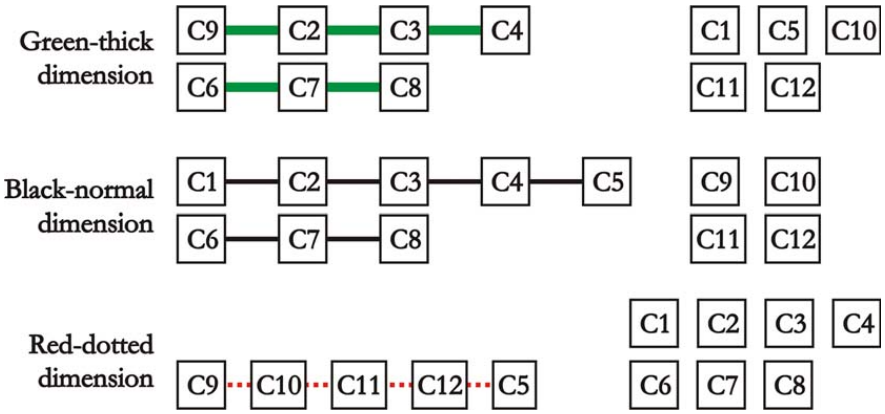

Fig. 4. Dimensions and ranks related to Fig. 3.

the system and enables a more significant navigation on the resources.

4. Navigation and authoring

The multilevel organization and the use of computational agents provide new possibilities for accessing sound documents. The users may choose the dimensions, in which they can make comparisons among the sources, using simple controls (gesture, pressing buttons or vocal devices) carried out on the selected input device. In this way, they can compare the audio signals (in time and/or frequency domain) of different sources with corresponding metadata, without interrupting the sound performance. The use of agents permits the virtual decomposition of the sources in their physical segments, the visualization of different versions, a partially automated analysis and the comparison.

4.1. Views on zz-structures

An meaningful contribute of zz-structures is the fact that they enable users to simplify their interaction with information, presenting both pieces of information and connections among them; in this way, users have the opportunity to access information from multiple perspectives and a variety of contexts.

The visualization of contexts and connections can be presented to the users using different methodologies and defining opportune views.

A view is a way of placing the cells on a screen. Generic views are designed to be used in a big variety of cases and usually show only few dimensions or few steps in each dimension.

Among them the most common are the rectangular views on two dimensions: the cells are placed on a Cartesian plane where the dimensions increase going down and to the right. Obviously some cells will not fit in these two dimensions and will have to be omitted. A cell is chosen and placed at the centre of the plane (cursor centric view); it assumes the role of focus. Moving the cursor horizontally and vertically enables the user to select a new cell as focus. In a row I-view, a rank is chosen and placed vertically. Then the ranks related to the cells in the vertical rank are placed horizontally. Vice versa, in the column H-view, a rank is chosen and placed horizontally and the related ranks are placed vertically. Different numbers denotes all the cells.

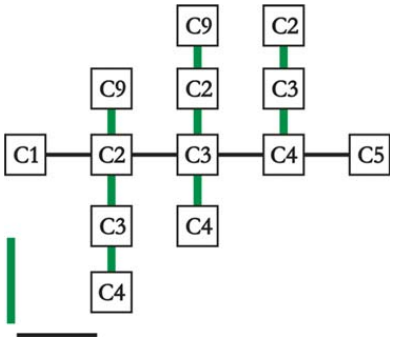

Fig. 5. A H-view related to zz-structure of Figs. 3–4.

An example of H-view related to zz-structure of Figs. 3 and 4 is shown in Fig. 5.

This view has size 5×5, and the central cell C3 as focus. In the bottom-left corner of the Fig. 5 are explicitly indicated the dimensions on vertical (thick) and horizontal (normal) axes. Note that the same cells may appear in different positions as they may represent the intersection of different dimensions.

Interested readers will find a deeper discussion about the views for zz-structures in Ref. [11].

4.2. Visualizing dynamic views

A H-view related to the *Strepiti dei Giudei* of San Fratello event is shown in Fig. 6.

The view proposes, horizontally, the dimension event, constituted by parallel ranks containing heterogeneous information related to each event and including, following Fig. 6, from left to right, musical instruments, dancers, videos, audio represented in time and frequency domains, but also year, textual descriptions, musicians, photos and

Fig. 6. A H-view related to the *Strepiti dei Giudei* of San Fratello.

so on. Vertical connections represent the related dimensions. The focus of view occupies the central position, and its selection highlights it, making it an active entity. Selecting the arrow in the bottom-right corner of the focus cell, a menu will show a set of selectable functionalities related to navigation (e.g., choice of visualization style––visible dimensions, size of view, personalization of view, etc.), to access and to authoring tool. The selection of a cell, different from the current focus, entails the visualization of a new view (of same size, style and on the same dimensions) in which the selected cell will occupy the central position of focus. Finally, clicking on one of the hidden cells (all that are shown in Fig. 6 with two grey borders) involves the shift of view in the selected direction.

All of the described operations are carried out from the agent present in the Fruition Layer, in collaboration with the agent of the Storage layer.

5. Conclusions

The goal of the integration between traditional music archives and Web 2.0 philosophy is not just to have fast access to information over distributed networks, but to have the capacity of creating new digital communities and resources, interrogating data and forming hypotheses about their meaning and wider contexts. This paper presented a contribute in this direction, proposing an original model for creating, accessing and authoring multi-dimensional documents, aggregating data and persons in a new, virtual, ethno-music community.

Currently I am working on the role and the use of tags, in order to face some open issues (such as the problem of consistency of tags in Web 2.0 environments), and suggest customized use of tags and folksonomies in the field of ethno-musicology, applying the theory related to recommending and adaptive systems.

References

[1] P. Casoto, A. Dattolo, N. Pudota, P. Omero, C. Tasso, Semantic tools for accessing, analysing, and extracting information from user generated contents: open issues and challenges, San Murugesan (Ed.), Handbook of Research on Web 2.0, 3.0 and X.0: Technologies, Business and Social Applications, IGI-Global: Hershey, PA, October 2009, ISBN: 978-1-60566-384-5 (Chapter 19).

[2] G. Vickery, S. Wunsch-Vincent, Participative web and user-created content: Web 2.0 wikis and social networking, OECD Science & Information Technology 15 (2007) i–128.

[3] N. Hu, R. Dannenberg, G. Tzanetakis, Polyphonic audio matching and alignment for music retrieval, in: Proceedings of the IEEE Workshop Applications of Signal Processing to Audio and Acoustics, 2003, pp. 185–188.

[4] R. Bod, Memory-based models of melodic analysis: challenging the gestalt principles, Journal of New Music Research 31 (1) (2002) 27–37.

[5] S. Canazza, A. Dattolo, A new data structure for old musical open works, In: Proceedings of the Eighth International Conference of New Interfaces for Musical Expression-NIME08, Genova, Italy, June 5–7, 2008, pp. 140–143.

[6] M. Katz, Capturing Sound: How Technology has Changed Music, UC Press, 2004.

[7] M. Katz, The second digital revolution in music, in: Talk for MLA-SAM Joint Conference Pittsburgh, Pennsylvania, February 26–March 4, 2007.

[8] T.H. Nelson, A cosmology for a different computer universe: data model, mechanisms, virtual machine and visualization infrastructure, Journal of Digital Information 298 (2004) 〈http://jodi.tamu.edu/Articles/v05/i01/Nelson/〉.

[9] S. Canazza, A. Dattolo, Open, dynamic electronic editions of multidimensional documents, in: Proceedings of the IASTED European Conference on Internet and Multimedia Systems and Applications—EuroIMSA 2007, Chamonix, France, March 14–16, 2007, pp. 230–235.

[10] G. Fugazzotto, A musical journey around sicily: music and anthropology, Journal of Musical Anthropology of the Mediterranean, No. 9. Venice: Fondazione Levi, 2004 〈http://www.fondazionelevi.org/ma/index/number9/fuga/sic_0e.htm〉.

[11] A. Dattolo, F. Luccio, A new concept map model for e-learning environments, in: J. Cordeiro, S. Hannoudi, J. Filipe (Eds.), Web

Information Systems and Technologies: Fourth International Conference, WEBIST 2008, Revised Selected Papers, LNBIP (18), Funchal, Madeira, Portugal, May 2008, Springer, Berlin, 2009, pp. 406–417.

[12] A. Dattolo, F. Luccio, Visualizing personalized views in virtual museum tours, in: Proceedings of the International Conference on Human System Interaction, May 25–27, Krakow, Poland, 2008, pp. 339–346.

[13] A. Dattolo, F. Luccio, A state of art survey on zigzag structures, in: Workshop on New Forms of Xanalogical Storage and Function, 20th ACM Conference on Hypertext and Hypermedia, Torino, June 29th, 2009, pp. 1–6.