APPLIED COMPUTING 2010

The 25th Annual ACM Symposium on Applied Computing

PROCEEDINGS OF THE 2010 ACM
SYMPOSIUM ON APPLIED COMPUTING

Sierre, Switzerland
March 22-26, 2010

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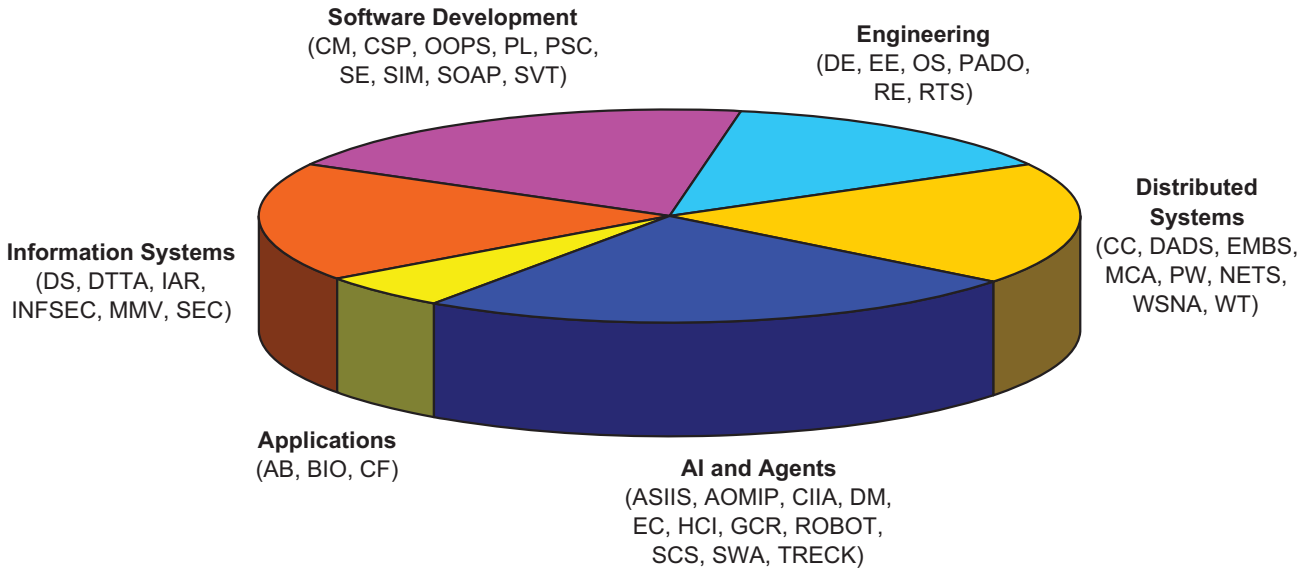

Hosted by
University of Applied Sciences Western Switzerland (HES-SO)
and
Ecole Polytechnique Fédérale de Lausanne (EPFL)

The Association for Computing Machinery, Inc.
1515 Broadway
New York, New York 10036

ACM ISBN: 978-1-60558-638-0 **ACM Order Number: 104102**

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Poster Papers

EDITORIAL MESSAGE
Special Track on Multimedia and Visualization

Ethan V. Munson, *University of Wisconsin-Milwaukee, USA*
Maria da Graça C. Pimentel, *Universidade de São Paulo, Brazil*

In the ACM Symposium of Applied Computing, the Multimedia and Visualization (MMV) track is concerned with principles, tools and processes that improve our ability to understand, create, manage, visualize and maintain multimedia in general and in interactive media in particular. The aim of this track is to bring together researchers from academia and industry who are actively engaged both in theoretical and practical aspects of these multidisciplinary themes. Further information on this year's track is available at http://www.icmc.usp.br/~acmsac/mmv10/.

The Multimedia and Visualization track's scope is deliberately quite broad. Submissions were encouraged whose research addressed any combination of issues in multimedia, visualization and interaction.

For ACM SAC'2010, the Multimedia and Visualization track received a total of 36 submissions. After the review of each paper by at least three reviewers from the program committee, ten submissions were accepted as full papers and one was accepted as poster. The accepted works cover many topics within the track's scope, ranging from image layout systems to semantics in hypermedia compositions to subjective video quality assessment in scalable video coding to image matting to video intelligent crop and scale to evaluating the sinuosity effect when visualizing simplified maps to music recommender to the discrimination of media moments and intervals to improved motion estimation module for scalable video processing photos from discs to generate the corresponding digital audio.

As in the previous edition of the MMV Track at ACM SAC'09, the Multimedia Tools and Applications journal (MTAP) will publish a special issue with papers from the ACM SAC'10 MMV track: after presenting their papers at the conference, authors of the five best papers will be invited to submit a substantially extended version for their work to the special issue.

Listening the Photos

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ABSTRACT

In the music field, an open issue is represented by the creation of innovative tools for acquisition, preservation and sharing of information. The strong difficulties in preserving the original carriers, together dedicated equipments able to read any (often obsolete) format, encouraged the analog/digital (A/D) transfer of audio contents in order to make them available in digital libraries. Unfortunately, the A/D transfer is often an invasive process.
This work proposes an innovative and not-invasive approach to audio extraction from complex source material, such as shellac phonographic discs: PoG (Photos Of Ghosts) is the new system, able to reconstruct the audio signal from a still image of a disc surface. It is automatic, needs of low-cost hardware, recognizes different rpm and performs an automatic separation of the tracks; also it is robust with respect to dust and scratches.

Categories and Subject Descriptors

H.5.5 [**Information Interfaces and Presentation**]: Sound and Music Computing—*Methodologies and techniques; Signal analysis, synthesis, and processing*

General Terms

Experimentation, Measurement

Keywords

Audio documents preservation, A/D transfer process, audio digital archives, automatically generated media, multimedia content analysis.

1. INTRODUCTION

The availability of digital archives and libraries on the Web represents a fundamental impulse for cultural and didactic development. Guaranteeing an easy and ample dissemination of the music culture of our times is an act of democracy that must be assured to future generations: the creation of new tools for the acquisition, the preservation, and the transmission of information is nowadays a key challenge for international archives and libraries communities [3]. Scholars and the general public have begun paying greater attention to the recordings of artistic events, but the systematic preservation and consultation of these documents are complicated by their diversified nature; in fact, the data contained in the recordings offer a multitude of information on their artistic and cultural life, that goes beyond the audio signal itself. From the first recording on paper, made in 1860 (by Édouard-Léon Scott de Martinville "Au Clair de la Lune" using his phonautograph), until to the modern Bluray Disc, what we have in the audio carriers field today, is a Tower of Babel: a bunch of incompatible analog and digital approaches and carriers – paper, wire, wax cylinder, shellac disc, film, magnetic tape, vinyl record, magnetic and optical disc, to mention only the principal ones – without standard players able to read all of them.

Nowadays, it is well-known that preserving carriers, maintaining dedicated equipment for the ever growing numbers of formats in playable condition, is hopeless, and that the audio information stored in obsolete formats and carriers risks of disappearing. On this basis, the traditional paradigm "preserve the original" evolved towards to "distribution is preservation" [6]: it proposes of digitizing the audio content and making it available using digital libraries technology. Now, if, on the one hand, it is evident the importance of transferring into the digital domain (active preservation) a least carriers in risk of disappearing, respecting the indications of the international archivist community [1, 13], on the other part, it became urgent to study and design new ways of organizing and sharing music archives, taking in account the radical revolution imposed by Web 2.0; in fact, the modalities of communication, meeting and information sharing between people have been strongly influenced by its advent [4].
This paper is part of a large big project, dedicated to propose innovative modalities for preserving and sharing audio information using social music archives; here we focus our attention only on a specific open issue: the definition of not-invasive methodology for the audio extraction from complex source material, such as shellac phonographic discs.

Contribute of this work. Automatic text scanning and optical character recognition are in wide use at major libraries. Yet, unlike texts, Analog/Digital (A/D) transfer of historical sound recordings is often an invasive process. The

SAC'10 March 22-26, 2010, Sierre, Switzerland.

Carrier	Period	Composition	Stocks
cylinder – recordable	1886-1950s	Wax	300,000
cylinder – replicated	1902-1929	Wax and Nitrocellulose with plaster ("Blue Amberol")	1,500,000
coarse groove disc – replicated	1887-1960	Mineral powders bound by organic binder ("shellac")	10,000,000
coarse and microgroove discs – recordable ("instantaneous discs")	1930-1950s	Acetate or nitrate cellulose coating on aluminum (or glass, steel, card)	3,000,000
microgroove disc ("vinyl") - replicated	1948-	Polyvinyl chloride - polyacetate co-polymer	30,000,000

Table 1: Typologies of analogue mechanical carriers

innovative contribute, discussed in this work, is the presentation of a new system, *PoG (Photos Of Ghosts)*, able to reconstruct the audio signal from a still image of a disc surface.

Case study domain. We present some experimental results applying our approach to *shellac discs*.
The shellac disc is a common audio mechanical carrier. The common factor with the mechanical carrier is the method of recording the information, which is obtained by means of a groove cut into the surface by a stylus modulated by the sound, either directly in the case of acoustic recordings or by electronic amplifiers. Mechanical carriers include: phonograph cylinders; coarse groove gramophone, instantaneous and vinyl discs. Tab. 1 summarizes the typologies of these carriers [10]. There are more then 1,000,000 Shellac discs in the worldwide audio archives; some of these contain music ever re-recorded (such as R&B, Jazz, Ethnic, Western classical).

The paper is organized as follows: in Section 2 we discuss related work; in Section 3 we propose PoG, our system of audio data extraction, while in Section 4 we present some experimental results through two cases of study. Finally conclusion and future works end the paper.

2. RELATED WORK

Some phonographs are able to play gramophone records using a laser beam as the pickup (laser turntable) [12]; this playback system has the advantage of never physically touching the record during playback: the laser beam traces the signal undulations in the record, without friction. Unfortunately, the laser turntables are only constrained to the reflected laser spot and are very sensitive to surface reflectivity, and susceptible to damage and debris.
Digital image processing techniques can be applied to the problem of extracting audio data from recorded grooves, acquired using an electronic camera or other imaging system. The images can be processed to extract the audio data. Such an approach offers a way to provide non-contact reconstruction and may in principle sample any region of the groove, also in the case of a broken disc.
These scanning methods have several advantages:
a) delicate samples can be played without further damage;
b) broken samples can be re-assembled virtually;
c) the re-recording approach is independent from record material and format (wax, metal, shellac, acetates, etc.);
d) effects of damage and debris (noise sources) can be reduced through image processing;
e) scratched regions can be interpolated;
f) discrete noise sources are resolved in the "spatial domain" where they originate rather than being an effect in the audio playback;
g) dynamic effects of damage (skips, ringing) are absent;
h) classic distortions (wow, flutter, tracking errors, etc.) are absent or removed as geometrical corrections;
i) no mechanical method needed to follow the groove;
j) they can be used for mass digitization.

In the literature, there are some approaches to the use of image processing to reconstruct sound [5, 8, 7]; in general, they can be based on: Electronic Cameras (2D or horizontal only view, frame based); Confocal Scanning (3D or vertical+horizontal view, point based); Chromatic sensors (3D, point based); White Light Interferometry (3D, frame based).

In [5] a high resolution analog picture of each side of the disk is shot. The film becomes an intermediate storage media. In order to listen to the sound, the picture is scanned using a high resolution circular scanner. The scanner is made by a glass turntable, a 2048-sensor CCD-linear camera is mounted on microscope lens above the glass. Light source located below the tray lightens the film by transparency.
Fadeyev et al. [8] apply a methodology partially derived from long standing analysis methods used in high energy particle and nuclear physics to follow the trajectories of charged particles in magnetic fields using position sensitive radiation detectors [9]. The device usedis the "Avant 400 Zip Smart Scope" manufactured by Optical Gauging Products. It consists of a video zoom microscope and a precision X-Y table. The accuracy of motion in the X-Y (horizontal) plane over the distance L (mm) is (2.5 + L/125) microns. The video camera had a CCD 6.4 mm x 4.8 mm containing 768x494 pixels of dimension 8.4 x 9.8 microns. With appropriate lenses installed it imaged a field of view ranging between approximately 260 x 200 microns and 1400 x 1080 microns.

Both the systems listed above are applied on shellac disc, both on mechanical and electric recordings. Although the high Signal to Noise Ration (SNR) of the audio signal extracted (more than 40 dB in a 78 rpm shellac disc), these techniques is not adapt in the case of typical european audio archive (they have small-medium dimension) because the hardware equipment is expensive.

In [7] is presented a full three-dimensional (3D) measurement of the record surface; in this study the color-coded confocal imaging method is considered, in particular the model

CHR150 probe, manufactured by STIL SA, is used. This probe is coupled to custom configured stage movement and read out through a computer. The stages are controlled by DC servo motors and read out by linear encoders. The linear stage resolution is 100 nanometers and the accuracy was 2 μm. This system get very interesting results in audio cylinder (both wax and amberol: see Tab. 1), but it needs several hours for scanning. Summarizing, it can be used for saving selected records, not for a mass saving.

3. AUDIO DATA EXTRACTION: PHOTOS OF GHOSTS (POG)

Photos of Grooves and HOles, Supporting Tracks Separation (Photos of GHOSTS or simply PoG) [11] is the system proposed in this work; it is distinguished by its following features:
- is able to recognize different rpm and to perform tracks separation automatically;
- does not require human intervention;
- works with low-cost hardware;
- is robust with respect to dust and scratches;
- outputs de-noised and de-wowed audio, by means of novel restoration algorithms.

The user can choose to apply an equalization curve among the hundreds stored in the system, each one with appropriated references (date, company, roll-off, turnover). The software automatically finds the disc centre and radius from the scanned data, using instruments developed in the consolidated literature on iris detection [11], for groove rectification and for tracks separation. Starting from the light intensity curve of the pixels in the scanned image, the groove is modeled and the audio samples are obtained [2]. The complete process is depicted in Fig. 1.

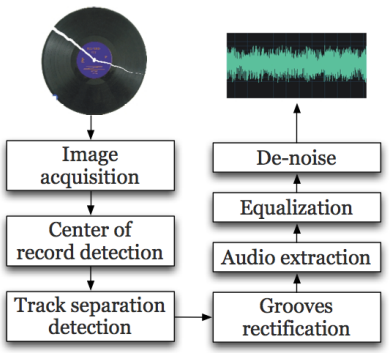

Figure 1: Photos of GHOSTS schema.

In particular, the system includes:

1. An innovative de-noise algorithm in a frequency domain [2] based on the use of a suppression rule, which considers the psychoacoustics masking effect.
   The spreading thresholds which present the original signal $x(n)$ are not known a priori and are to be calculated. This estimation can be obtained by applying a noise reduction STSA standard technique leading to an estimate of $x(n)$in the frequency domain; the relative masking thresholds m_k, defined as the non negative threshold under which the listener does not perceive an additional noise, can be calculated by using an appropriate psychoacoustic model. The obtained masking effect is incorporated into one of the EMSR technique [2], taking into consideration the masking thresholds m_k for each k frequency of the STFT transform. Then is created a cost function depending on m_k: its minimization gives the suppression rule for the noise reduction. This cost function can be a particularization of the mean square deviation to include the masking thresholds, under which the cost of an error is equal to zero.

2. Unlike the methods listed in Sec. 2, 225 different equalization curves, which cover almost all the electric recordings, since 1925.

3. The design and the realization of ad-hoc prototype of a customized (very) low-cost scanner device; it is equipped with a rotating lamp carriage in order to position every sector with the optimal alignment relative to the lamp (coaxially incident light). In this way we improved (from experimental results: more than 20%) the accuracy of the groove tracking step.

PoG may form the basis of a strategy for:
a) large scale A/D transfer of mechanical recordings, retaining maximal information (2D or 3D model of the grooves) about the native carrier;
b) small scale A/D transfer processes, where there are not sufficient resources (trained personnel and/or high-end equipments) for a traditional transfer by means of turntables and converters;
c) the active preservation of carriers with heavy degradation (breakage, flaking, exudation).

4. EXPERIMENTAL RESULTS

In this section we present our experimental results of applying the above described technique related to audio data extraction. We conducted a series of experiments with real usage data from different international audio archives. A number of examples generated by the method described in this paper is available at: `http://avires.dimi.uniud.it/tmp/DL/Experimental_Results.html`

4.1 Case Study #1: Strange Fruit

As first case study, we selected the 1939 double-sided 78 rpm shellac disc *Commodore, 526-A, WP24405A* and focused our attention on the song *Strange Fruit*.

The performers are Frank Newton & Café Society Band (Commodore, MT 117): Kenneth Hollon (ts), Sonny White (p), Jimmy McLin (g), John Williams (b), Eddie Dougherty (d), Billie Holiday (v). New York, 20 April 1939.

Because of the microphones setup, the audio quality of the recording is below to the standard of that time. In its first recordings, the Commodore Company was not able to afford the same equipment provided by CBS and RCA. The 78 rpm considered is very damaged. Both sides have scratches. Moreover, some areas are particularly dark: we hypothesized that this corruption is caused by some washes (made before the disc was acquired by the audio archive of one of the author of this paper) in which chemical aggressive substances are used. The corruptions cause evident distortions if the disc is played by means a stylus.

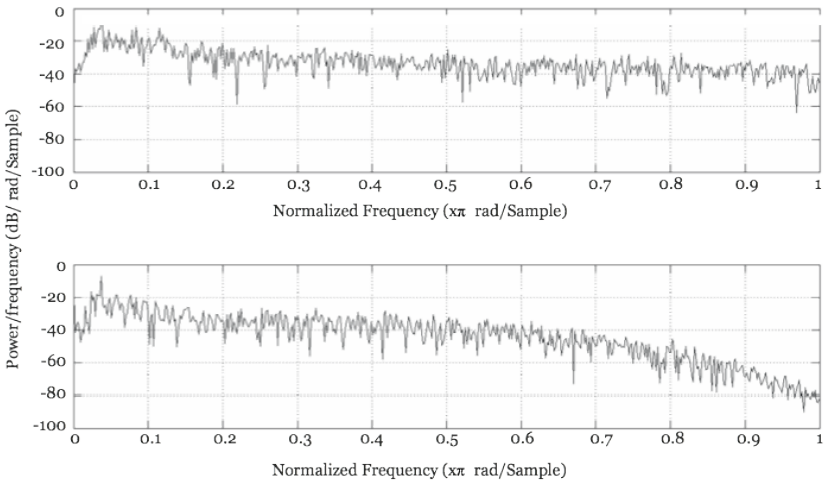

Figure 2: Case study #1: Periodograms of the audio signals sampled by means of turntable (top) and synthesized by means of PoG (bottom). Window: 2048 points. Analysis interval: 13s - 18s.

The audio signal was extracted in two ways:

1. By means of the Rek-O-Kut-Rodine 3 turntable; the A/D transfer was carried out with RME Fireface 400 at 44.1 kHz, 16 bit; no equalization curve has been applied.

2. Using PoG system; the image was taken at 4800 dpi, 8 bit grayscale, without digital correction.

Finally, the clicks were removed using the Extended Kalman Filter (EKF) based algorithm as described in [2] and the hiss was reduced by means a de-noise algorithm in a frequency domain based on the use of a suppression rule, which considers the psychoacoustics masking effect (Sect. 3). Then, the signal was resampled at 44.1 kHz.

Fig. 2 shows a periodogram of both signals. In audio frequency range there aren't artifact caused by PoG; moreover, it can be noticed the SNR enhancement obtained by means of de-noised algorithm.

4.2 Case Study #2: I-Feel-Like-I'm-Fixin'-to-Die Rag

As second case study, we selected the disc *Talking Issue Rag Baby No. 1: songs of opposition*, (Volume 1, Issue A: RAG-1001, 1965) by Country Joe and the Fish, and considered the song (on side 1) *I-Feel-Like-I'm-Fixin'-to-Die Rag*.

The performers are Carl Schrager (washboard, kazoo), Bill Steele (b, washtub b), Barry Milton (g), Joe McDonald (v, g), Pete Krug (v, g), Mike Beardsle (v).

The song is one of the most popular Vietnam protest songs from the 1960s. The melody is *inspired* at the Kid Ory's classic *Muskrat Ramble* as recorded by Louis Armstrong & his Hot Five in 1926.

The disc, in possession of one of the author of this paper, is broken (see Fig. 4) and so it is not playable by a turntable: the audio signal was then synthesized using the PoG system. The image was taken at 4800 dpi, 8 bit grayscale, without digital correction. The signal was equalized using the RIAA curve (the disc is recorded in 1965). The clicks are removed by means the EKF filter: because the disc quality is high and the carrier is in good condition (with the exception of the heavy corruption that has caused the break) we didn't apply the hiss reduction. The signal was resampled at 44.1 kHz.

Figure 4: Case study #2: Cover and disc surface.

The periodogram of the signal and the signal in the domain of the time are shown in Fig. 3: we note that the heavy corruption doesn't cause evident artifact in the audio signal synthesized starting from the still image.

5. CONCLUSION AND FUTURE WORK

The system discussed in this work, PoG, proposes a new approach for extracting audio signal from complex source material. The methodology is not invasive and innovative; the audio signal is reconstructed using a still image of a disc surface; we focused our discussion on the shellac phonographic discs, showing as PoG guarantees good performances also when the discs have heavy corruptions and supports different formats (rpm, diameter, channels number) without to change the equipment setup.

Our aim is to study innovative models for preserving and sharing audio documents in the context of Web 2.0/3.0. This paper represents a first step in this direction; starting from PoG, future works will focus on:

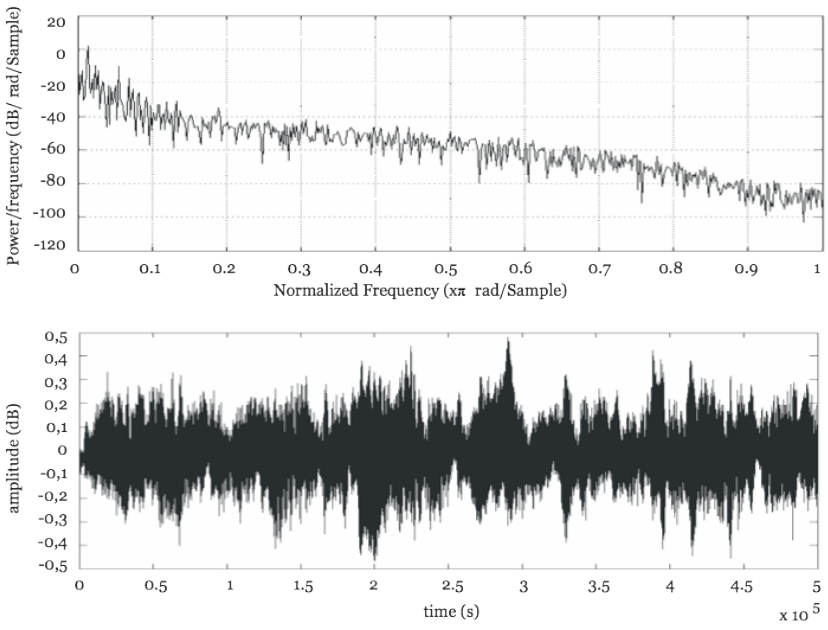

Figure 3: Case study #2: Periodogram of the audio signal synthesized by means of PoG (top). Window: 2048 points. Analysis interval: 21s - 26s. In the bottom, the signal (de-clicked) in time domain. Analysis interval: 12.5s - 23s.

- we are carrying out a deep analysis and comparison among the different models and PoG;
- we are currently actively working for a first release of a social network prototype, in which PoG will be used as a new tool for sharing and preserving audio documents.

6. ACKNOWLEDGMENTS

This work was partially supported by the Foundation Arena di Verona within the framework of the joint cooperation project REVIVAL, 2009-2010.

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