



# Computational Analysis of the Live Music Archive

## Document Version

Final published version

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## Citation for published version (APA):

Bechhofer, S., Dixon, S., Fazekas, G., Wilmering, T., & Page, K. (2014). *Computational Analysis of the Live Music Archive*. Poster session presented at ISMIR2014, 15th International Society for Music Information Retrieval Conference, Taipei, Taiwan.

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# COMPUTATIONAL ANALYSIS OF THE LIVE MUSIC ARCHIVE

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## ABSTRACT

The Computational Analysis of the Live Music Archive (CALMA) project aims to facilitate investigation and scholarship related to live music through development of a Linked Data service combining metadata captured during deposition of audio to the Internet Archive, with computational analyses over these recordings through feature extraction, clustering, and classification. In this poster and demonstrator we introduce the architecture, tools, and data structures we have developed to create this combined resource, and provide a first release of the dataset including provenance metadata to assist its interrogation and reuse. We also show the early results of questions assessed over the data that (i) aid resolution of uncertain metadata, identification of potential errors, and validation of existing entries, and (ii) provide metrics for broad patterns in performance variation that can be used to select subsets within the data for further longitudinal and musicological study.

## 1. INTRODUCTION

The Live Music Archive (LMA)<sup>1</sup>, part of the Internet Archive, is an online resource providing access to a large community-contributed collection of live recordings. Covering nearly 4,000 artists, chiefly in rock genres, the archive contains a growing collection of over 100,000 live recordings of concerts made openly available with the permission of the artists concerned. Audio files are available in a variety of formats, and each recording is accompanied by basic metadata describing information including dates, venues, set lists and the provenance of the audio files – although this is gathered using free text fields entered by the uploader.

In earlier work [1] we introduced a linked data service<sup>2</sup> for metadata about the LMA, known as *etree*. The collection is published using a layered approach. Core metadata describing the resources is essentially published “as is”,

<sup>1</sup> <https://archive.org/details/etree>

<sup>2</sup> <http://etree.linkedmusic.org/>



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with data provided by LMA translated to an RDF form, using appropriate vocabulary terms (for example, the label associated with a particular performance is represented using `skos:prefLabel`). Additional information asserting mapping relationships to other collections such as MusicBrainz, GeoNames or last.fm is then added. This layering ensures that the source information is kept intact, with the provenance of additional mappings made explicit.

## 2. COMPUTATIONAL ANALYSIS

We have supplemented this metadata with a computational analysis of the corresponding LMA audio data using Sonic Annotator, deploying a suite of existing VAMP plugins on multi-core compute servers [2, 3]. The initial set of VAMP plugins used is given in Table 1. We employ Python scripts to control the feature extraction process. The audio material is retrieved automatically using the *internetarchive* library<sup>3</sup>, which provides a Python interface to the Internet Archive.

A trial collection of audio was selected using a SPARQL query over metadata constraints: of artists with between 200 and 1000 concerts and also with a song title repeated more than 100 times across those performances. This yielded over 16,000 matching concerts with 16-bit loss-less audio available. At the time of writing over 10,000 of these concerts have been analysed for features, with numerous artists having sub-collections of song titles that have been performed over 100 times, e.g. there are recordings of 41 “Bob Walkenhorst” songs that each have over 100 performances across 445 concerts, 8 songs performed by “The Brew” over 100 times across 253 concerts, 14 100-performance songs by “Cracker” over 322 concerts, 32 100-performance songs by “Drive By Truckers”, 22 by “Guster”, and so on.

## 3. DATA INVESTIGATION

With the subsets of audio selected and analysed per the previous section, it is possible to investigate questions across multiple recordings of the same song by the same artist. The first questions posed fall within two use cases:

(i) Identifying collections of audio which highlight a variation in performance for further study. For example, is there a pattern in the change of performance tempo of the

<sup>3</sup> <https://pypi.python.org/pypi/internetarchive>

VAMP Plugin	Feature
nnls-chroma:chroma [4] <sup>1</sup>	12-dimensional chromagram
nnls-chroma:chordino:simplechord <sup>1</sup>	estimated chord times and labels
qm-mfcc:coefficients <sup>2</sup>	mel-frequency cepstral coefficients
qm-tempotracker:beats <sup>2</sup>	estimated positions of metrical beats
qm-tempotracker:tempo <sup>2</sup>	song tempo
qm-similarity:beatspectrum <sup>2</sup>	rhythmic autocorrelation profiles
qm-keydetector:key <sup>2</sup>	estimated key for each key change
qm-segmenter:segmentation <sup>2</sup>	estimated boundaries of structurally consistent segments
segmentino:segmentation [5] <sup>3</sup>	(alternative) structural segmentation
bbc-speechmusic-segmenter:segmentation <sup>4</sup>	estimated boundaries between speech and music
vamp-libxtract <sup>5</sup>	low-level features, e.g.: standard deviation, crest factor, spectral inharmonicity, loudness, non-zero count, spectral centroid

<sup>1</sup> <http://isophonics.net/nnls-chroma>

<sup>2</sup> <http://vamp-plugins.org/plugin-doc/qm-vamp-plugins.html>

<sup>3</sup> <http://www.isophonics.net/segmentino>

<sup>4</sup> <https://github.com/bbcrd/bbc-vamp-plugins>

<sup>5</sup> <http://code.soundsoftware.ac.uk/projects/vamp-libxtract-plugins>

**Table 1.** Initial set of VAMP Plugins used in the feature extraction process.

same song by the same artist over time? Is there a significant increase or decrease in tempo for repeat performances at specific venues, i.e. locations where performances are faster or slower? From length of performance in combination with tempo can we infer structural changes – are verses or choruses repeated more or less by an artist over time?

(ii) The metadata from LMA can be noisy or incomplete, with missing or erroneous labelling. Can audio features be used to provide authority in resolving uncertain metadata alignment? Do features confirm that all songs marked with the same title share the same characteristics, or might there be some mislabelling? Can content-based analysis provide confidence that two songs are sufficiently similar to override differences in metadata labelling which may be due to mis-spelling or errors on entry?

#### 4. LATE-BREAKING RESULTS AND DEMONSTRATOR

Scripts have been written to extract metadata from the feature extraction output, creating RDF that links the analysis to the URI identifiers used by the existing etree service. Provenance metadata is saved that captures the feature extraction process including the plugins and parameters used. This is automatically saved into a structured series of directories and file identifiers, including the “raw” feature output, which can be packaged into a self-describing archive of the dataset, or as a live website queryable via SPARQL.

We present a demonstrator of the system showing the live Web based version of the dataset and the integration with the Linked Data etree service.

#### 5. ACKNOWLEDGEMENTS

This work was supported by a grant from the EPSRC Semantic Media Network.

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