MULTI-MEDIA RECORDINGS OF TRADITIONAL GEORGIAN VOCAL MUSIC FOR COMPUTATIONAL ANALYSIS

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ABSTRACT

Traditional multipart-singing is an essential component of the national identity of Georgia. It has been an active field of ethnomusicological research since more than 100 years, with a whole series of thematically very diverse research questions. Here, we report on the generation of a new research corpus of traditional Georgian vocal music collected during a three-month field expedition in 2016. It employs new and partially unconventional field recording techniques and is intended particularly for the application of modern computational analysis methods. To circumvent the source separation problem for multiple singing voices in field expeditions, we used larynx microphones to record skin vibrations close to the larynx (additionally to using conventional audio and video equipment). The resulting multi-media recordings comprise audio and video material for more than two hundred performances, including more than fourteen hundred audio tracks based on different types of microphones (headset, larynx, ambient, directional), video tracks, as well as written documents of interviews with the performers. We demonstrate that the systematic use of larynx microphones, which to our knowledge has never been used before on a larger scale in ethno-musicological field expeditions, opens up new avenues for subsequent computational analysis regarding a multitude of aspects including pitch tracking, harmonic and melodic analysis, as well as for documentation and archiving purposes.

1. INTRODUCTION

There have been many efforts in the past to document and record the rich musical heritage of traditional Georgian polyphonic music, pioneered by phonograph recordings more than a century ago. However, many of them have been lost over the years and the available historic audio recordings are often of insufficient quality for the application of modern, quantitative analysis techniques. A notable exception, regarding the applicability of computerized analysis tools, is the collection of historical recordings by master chanter Artem Erkomaishvili. This dataset was processed and enriched by features informatically extracted from the recordings, see Müller et al. (2017) (accompanied by a website [1]).

In 2015, a pilot project was carried out to test the usefulness of body vibration recordings for ethnomusicological purposes, see Scherbaum (2016). Based on this experience, we started during the summer of 2016 to collect a new set of field recordings of traditional Georgian vocal music. The regional focus of our field work was on Upper Svaneti, which is one of the rare regions in the crossroads of Europe and Asia where very old (presumably pre-Christian) traditions are still cultivated as part of daily life. Svan songs as parts of these rituals occupy a special place within the Georgian music and are still maintained in a comparatively original form due to the remote geographic location. The style of Svan multi-part singing has been described in different terms as chordal unit polyphony Aslanishvili (2010), or drone dissonant polyphony Jordania (2010), and the judgments regarding the importance of the (moving) drone and/or of the role of dissonances differ between authors, e. g. between Dirr (1914) and Jordania (2006). Consensus, however, exists on the hypothesis that Svan music represents the oldest still living form of Georgian vocal polyphony.

There have been considerable efforts in the past to record traditional Svan music, first with phonographs, later with tape recorders. Already more than 100 years ago, Dirr (1914) discussed the musical characteristics of phonograph recordings from Svaneti (North-Western Georgia), which had been collected by Paliashvili (1909). Unfortunately, most recordings of Svan songs from the early days of the last century have not survived the ravages of time. The few audio files obtained are mostly in very poor quality. On the other hand, the Tbilisi Conservatory has also made recordings since the 1950s. These recordings, however, were lost during construction work in the 1990s. It should also be noted that during the 1980s, a set of recordings with the Mestia Regional Folk Song and Dance Ensemble Riho were made in the voice recording studio Melodia. These recordings, however, were only released very recently, see Khardziani (2017). A small number of more recent audio recordings were made by ethnomusicologists Malkhaz Erkvanidze and Keti Matiashvili in 2004 (recordings of approximately 25 songs in Lower Svaneti), and between 2007 and 2010 by the State Center of Folklore under the supervision of ethnomusicologist Nato Zumbadze, both in Lower and Upper Svaneti, partly with several microphones and in a mobile recording studio. In addition, within the crowd-funded Svan Recording Project performed by American singer Carl Linnich in 2010 with members of the Riho Ensemble in Lengeri, 32 songs were supposedly recorded. However, it is not known to us if this project was completed. In conclusion, before our own field expedition described in this paper, the publicly available audio material from traditional Svan songs known to us was very limited in number and quality.

[1] https://www.audiolabs-erlangen.de/resources/MIR/2017-GeorgianMusic-Erkomaishvili

2. NEW RECORDINGS OF SVAN MUSIC

During the summer of 2016, Frank Scherbaum and Nana Mzhavanadze performed a field expedition to record Georgian vocal music in Svaneti and other regions in Georgia. The recordings cover a wide range of examples of traditional Georgian singing, praying, and rare examples of funeral lament (roughly 120 pieces in total). The technical quality of the recordings is good to excellent. All the recordings were done as multi-media recordings in which a high resolution (4K) video stream is combined with a stream of 3-channel headset microphone recordings (one for each voice group), a stream of 3-channel larynx microphone recordings (one for each voice group as well), and a conventional stereo recording. The systematic use of larynx microphones, which to our knowledge has never been done before in ethnomusicological field expeditions, was motivated by the results of Scherbaum et al. (2015). Larynx microphone recordings allow the undistorted documentation of the contribution of each singer while all of them are singing together in their natural context. Secondly, larynx microphone recordings contain essential information of a singer's voice regarding pitch, intonation, timbre and voice intensity, which allows for using computer-based ways to document and analyze oral-tradition vocal music in new ways, e. g to perform computerized pitch analysis to document the pitch tracks (including the microtonal structure), to study the pitch inventory and scales used and the interaction between singers, see Scherbaum (2016). Each recording session was accompanied by extensive interviews of the performers conducted by Georgian ethnomusicologist Nana Mzhavanadze as described in Scherbaum & Mzhavanadze (2017).

All the initiatives to systematically record traditional Svan music before our field expedition have in common that the recordings were purely acoustic. Even with recordings using separate microphones (as in some of the more recent projects), the separability of the individual voices is problematic. In the context of our own work on the generation and propagation of body vibrations during singing described by Scherbaum et al. (2015), we have tested the acoustic separability of individual voices with directional microphones under studio conditions and found that this becomes problematic even under idealized conditions when singers sing with differing intensity (which they definitely do in Svaneti). In conclusion, the acquired research corpus seems optimally suited to address a large number of diverse research questions.

2.1 Recording Locations

The field recordings were done in 25 recording sessions spread over the summer months (July – September) of 2016. The recording locations are shown in Fig. 1.

Since our emphasis was on (Upper) Svaneti, the vast majority of the recording sessions involved Svan singers or people performing Svan prayers, either in Svaneti or in Svan settlements outside Svaneti (Didgori, Tsalka, and Udabno). In Sessions 3 and 4 we recorded two groups of Gurian singers (Shalva Chemo and Amaghleba in Ozur-

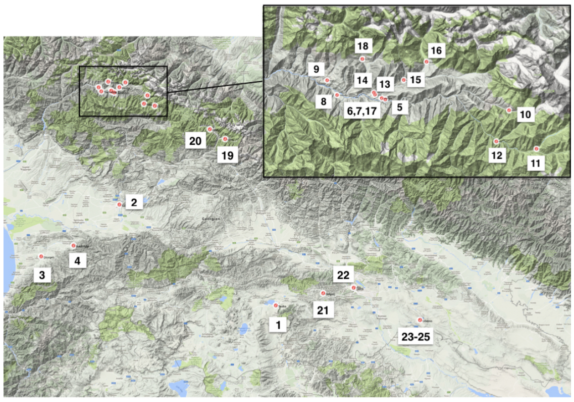


Figure 1: Location of the recording sessions.

geti and Bukitsikhe, respectively), while in Session 22 in Tbilisi we used the opportunity to record singers from a women's group of ethnomusicologists (Mzetamze) to perform songs from various regions. In addition, we recorded singers in the villages of Glola and Ghebi in the upper part of the Rioni river valley (which now belongs to Racha). In former days, this region used to be part of Svaneti as well.

2.2 Recording Equipment

Our standard recording setup consisted of three DPA 4066-F headset microphones and three (modified) Albrecht AE 38 S2 larynx microphones (one set of headset/larynx for each singer), which were recorded using an eight-track Zoom F8 field recorder. In addition, a stereo recorder (Olympus LS5) was used to record each group of singers from an approximately 2-m distance. Each session was documented by video in 4 K resolution using a Sony AX 100 video camera. The corresponding audio signal was either recorded by the internal stereo microphone (in cases of small rooms) or with a Sony XLR-K2M directional microphone (in cases where the camera was placed at larger distances from the singers). Finally, still photos and occasionally short videos were taken with a Sony HX90 camera and an iPhone 6. A Zoom Q4 video camera was occasionally used for interviews.

2.3 Pre-Processing

For each performance, audio, larynx microphone, and video tracks of similar length were manually cut and saved to disc. Subsequently, all tracks were aligned in time using the Plural Eyes software (Red Giant Inc.) and underwent a first visual quality control. In total, the collection contains 1444 files (tracks) of different media types (video, audio, and larynx microphone recordings) belonging to 216 different performances. Among them are 37 performances of prayers and 11 performances of funeral songs (Zari). The rest is referred to as songs (in a very general sense). Some of the songs were recorded several times by different ensembles, e. g. Kriste Aghsdga and Jgragish, each five times, Vitsbil-Matsbil, Tsmindao Ghmerto (the funeral version) and Dale Kojas, each four times. Overall, the distribution of song types of recorded songs is quite diverse. Hymns and ballads alone already make up one half of the song inventory. One quarter consists of dance songs, table songs, and mourning songs. Eleven recordings of funeral songs (Zari) were made in different contexts. Four of them were recorded during actual funerals (Session numbers 12 and 13 in Kala and Latali, respectively), while the rest were performed during conventional recording sessions.

3. REUSABILITY OF THE CORPUS

In the context of creating a research corpus for computational analysis, Serra (2014) discusses five criteria (purpose, coverage, completeness, quality, and reusability) relevant to its quality. The first four of them were already discussed in the previous chapter. Regarding the fifth criterion (reusability), we are following two strategies.

First, a curated version of the pre-processed tracks, together with the original audio and video material as well as descriptive material related to the individual recording sessions is permanently stored within the long-term archive of regional scientific research data (LaZAR), hosted at the University of Jena/Germany, see Scherbaum et al. (2018). It is accessible for research and other non-commercial purposes through a searchable web-interface [2]. The main purpose of this archive is the long-term preservation of the collected material.

Second, due to the systematic use of larynx microphones, the collected material allows for new ways to employ computational methods from audio signal processing and music information retrieval (MIR). It forms an important basis of the research project "Computational Analysis of Traditional Georgian Vocal Music" (funded by the German Research Foundation for the period 2018-2021), hereafter referred to as GVM project. In order to facilitate the access to the collected material within the framework of this project, e. g. to visually study a particular recording session or to perform conventional analysis such as transcription of the lyrics, we have developed a web-based interface with search, navigation, visualization, and playback functionalities. Based on the trackswitch.js architecture (see Werner et al. (2017)), this interface allows a user to play back all the media channels (audio, larynx microphone recordings, video) and seamlessly switch between different audio tracks. A preliminary version was demonstrated by Scherbaum et al. (2018) and can be accessed at the accompanying website [3], see also Fig. 2.

4. ANALYSIS EXAMPLES

In the framework of the GVM project, we aim to improve the understanding of traditional Georgian vocal music by using computational tools. In the following, we will give a few examples how the collected multi-media recordings can be used for this purpose. The first aspect which we will discuss is how the larynx microphone tracks of a performance can be used to determine the "tuning system" employed by the singers. For traditional Georgian vocal music, the topic of "tuning system(s)" or –in more general terms –"tonal organization", has been a matter of intense debate for a long time (cf. Tsereteli & Veshapidze (2014) or Erkvanidze (2016)). The second aspect which we will address is how a combination of audio tracks and larynx microphone tracks can be used to explore new ways to digitally represent polyphonic non-Western orally transmitted music. As musical example we have chosen the Gurian song "Chven Mshvidoba" recorded with the group "Shalva Chemo" in Ozurgeti. Because of its musical complexity, this song is one of the more challenging examples to analyze.

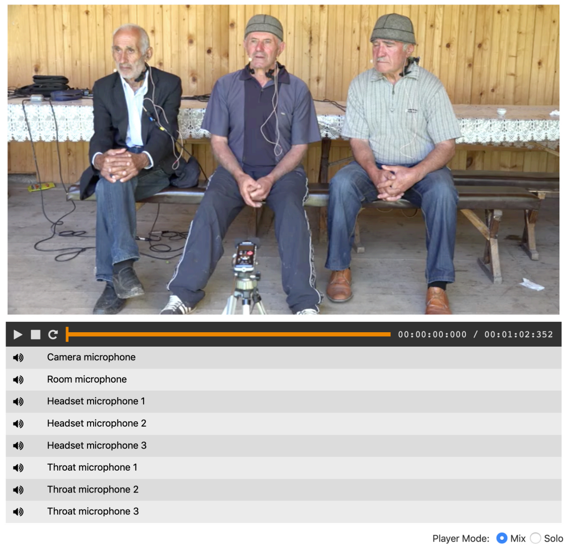


Figure 2: Web-repository interface. Shown is a screendump of the multi-track player.

4.1 Tonal Organization

As was demonstrated by Scherbaum et al. (2015), there is essentially no cross-talk between larynx microphone recordings for different singers. Therefore, the F0-trajectories for the individual voices can be obtained by using monophonic pitch trackers such as the pYIN algorithm (see Mauch & Dixon (2014)). Such a trajectory is shown in Fig. 3 for the top voice of the song "Chven Mshvidoba".

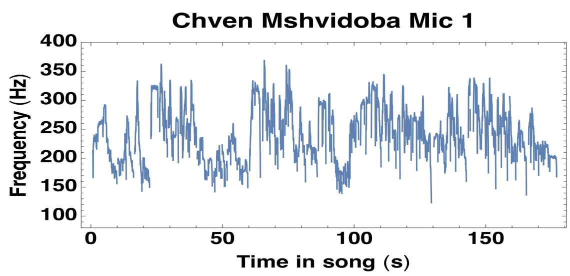


Figure 3: F0-trajectory of the top voice of the song "Chven Mshvidoba".

[2] https://lazardb.gbv.de/search
[3] https://www.audiolabs-erlangen.de/resources/MIR/2018-ISMIR-LBD-ThroatMics

For the analysis of the set of pitches used, we are only interested in stable segments of the F0-trajectories (where one can perceive a stable pitch) and not in utterances corresponding to very short transient signals. A computationally very efficient way to remove them is by morphological filtering as described by Vavra et al. (2004). In practice, the process consists of calculating the dilated and eroded F0-trajectory and considering only those time windows where the difference between the two stays below a chosen threshold (black solid lines in Fig. 4).

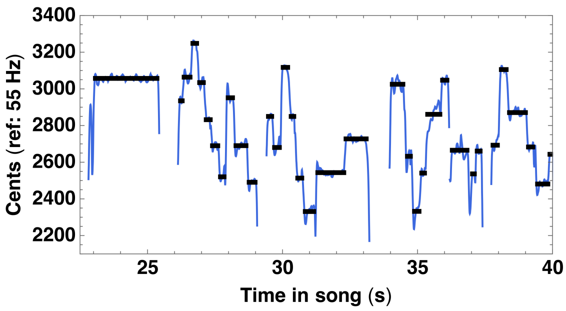
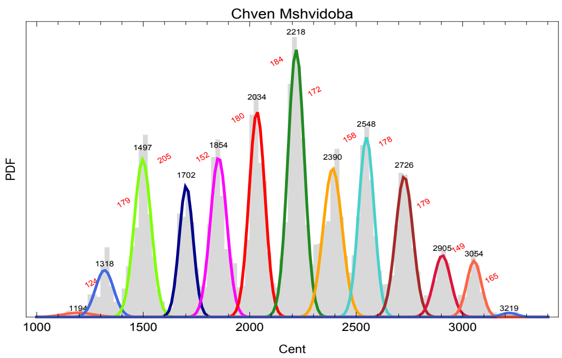


Figure 4: Determination of stable pitch elements (black solid lines) from F0-trajectories by morphological filtering.

Fitting a Gaussian mixture distribution to the set of F0 samples coming from the stable pitch segments from all three voices results in the probability density function (PDF) shown in the top panel of Fig. 5.

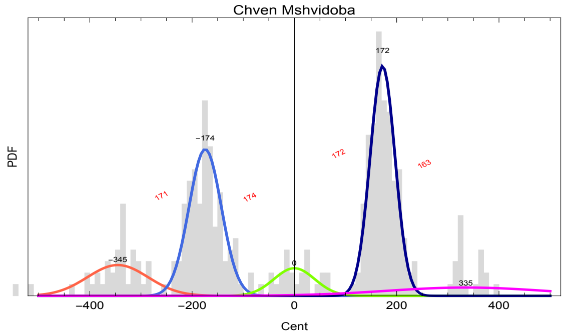


	μ	σ
0.0050502	1194.32	72.2934
0.0330392	1318.24	42.5507
0.10476	1497.46	40.1996
0.0709743	1701.58	32.6678
0.102658	1853.95	38.815
0.126277	2034.26	37.0818
0.169965	2217.89	38.3523
0.109547	2389.71	44.5427
0.107995	2548.13	36.2487
0.0946024	2725.8	40.5899
0.0405386	2904.53	39.6784
0.0320591	3053.52	34.474
0.0025343	3218.55	37.6776

Figure 5: Pitch distribution of the song "Chven Mshvidoba". The unit of pitch is in cents, relative to 55 Hz.

Each mixture component in Fig. 5 is displayed in a different color. The weights, mean values (μ), and standard deviations (σ), for the individual components are given in the first, second, and third column of the table in the bottom panel of Fig. 5, respectively. The mean values are also shown as black numbers in the top panel of Fig. 5. The tilted red numbers in the top panel show the differences between the mean values of neighboring individual mixture components. Fig. 5 describes the melodic pitch inventory which is used by the singers.

The distribution of the melodic steps used, calculated as the pitch difference between subsequent stable pitches, is given in Fig. 6. It shows that the melodic progression in this song is primarily stepwise and rarely contains melodic jumps. The most prominent melodic step sizes are approximately 173 cents with the upwards steps showing less variability than the downward ones.



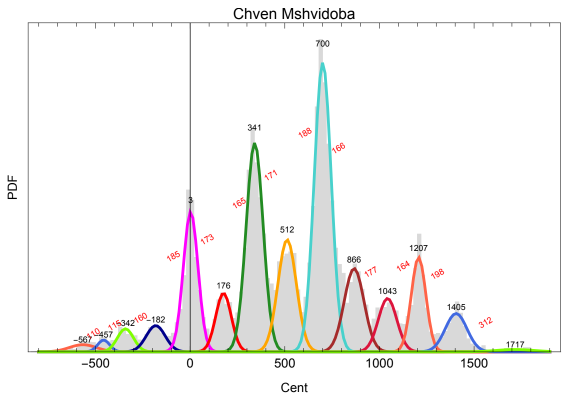
	μ	σ
0.126423	−345.391	59.2326
0.321274	−174.405	31.6349
0.0762331	−0.140965	39.8197
0.387171	172.391	24.3321
0.088899	335.266	154.438

Figure 6: Distribution of melodic step sizes in cents (relative to 55 Hz) of the song "Chven Mshvidoba". The table in the bottom panel shows the parameters of the Gaussian mixture model used to quantify the distribution. For further details see explanations for Fig. 5.

To complete the discussion of the tonal organization, Fig. 7 shows the distribution of harmonic intervals which was calculated from all concomitant intervals in all three voices. Figs. 5 to 7 quantitatively describe the complete tuning system as it was used by the singers. Representing the distributions in Figs. 5 to 7 as Gaussian mixture distributions is motivated by the fact that this facilitates the subsequent analysis, e. g. the comparizon of different performances, enormously. It is interesting to note in Fig. 7 that the mixture component representing the harmonic fifth (turquoise color) has a mean value of 700 cents, which approximately corresponds to just tuning (702 cents). This value differs by nearly 20 cents from a melodic fifth which would be obtained by three subsequent melodic steps of approximately 173 cents (cf. Fig. 6). This is believed to be achieved by intonation adjustments of the individual voices (cf. Nadel (1933)), a phenomenon which is also reflected in the variability of the melodic step size distribution shown in Fig. 6 and which we intend to study in detail within the GVM project.

4.2 Digital Representation of Polyphonic Non-Western Oral-Tradition Vocal Music

In the final example, we will illustrate how a combination of audio and larynx microphone tracks can be used



	μ	σ
0.00983433	−567.17	71.1854
0.00721699	−457.271	31.6286
0.0189798	−342.017	42.6342
0.0253974	−182.018	50.1485
0.105064	2.60931	38.8967
0.046553	176.039	41.1946
0.180325	340.77	44.7445
0.105827	512.304	48.9605
0.249322	700.38	44.6899
0.0842518	866.137	52.4137
0.0502955	1042.93	48.8734
0.0701926	1206.92	38.542
0.0422472	1405.08	57.1401
0.0044934	1716.91	98.6081

Figure 7: Distribution of harmonic interval sizes of the song "Chven Mshvidoba". The table in the bottom panel shows the parameters of the Gaussian mixture model used to quantify the distribution. For further details see explanations for Fig. 5.

to digitally represent the song "Chven Mshvidoba" in a form which overcomes some of the problems related to classical transcriptions. From the spacing of the mean values of the individual mixture components in Fig. 5 it can be seen that the tuning which is used for the song "Chven Mshvidoba" is significantly different from the 12 tone-equal-temperament (12-TET) system, where the pitch spacing would be expected to be either 100 or 200 cents. It would therefore be inappropriate to transcribe this song in western 5-line staff notation (which is based on the 12-TET system).

The representation which we have chosen here is in form of a movie ("pitch track movie")[4] in which the viewer listens to an audio mix from the three headset microphones while watching a vertical cursor (which represents the actual audio playback position) horizontally moving over a display window of a chosen duration (here 25 sec) (see Fig. 8). Shown in the display window are the stable pitch elements (horizontal bars) determined from the larynx microphone tracks together with the corresponding F0-trajectories segments (wiggly lines). The horizontal axis is time in seconds (with respect to the start of the song) while the vertical axis is in cents (with respect to a chosen reference frequency in Hz). In the right part of the display window the pitch distribution shown in Fig. 5 (rotated by 90 degrees) is plotted as a reference for the tuning system used. The used tuning system is also visualized by a set of horizontal lines grid lines, corresponding to the mean values of the individual mixture components (cf. μ values in the table in the bottom panel of Fig. 5).

Whenever the playback cursor falls within a stable pitch segment in any voice, the corresponding pitch element is highlighted and a horizontal bar is superimposed on the rotated pitch distribution. At the same time, the pitch of the lowest stable pitch element is shown within a green ellipse, subscripted by the interval of the second lowest stable pitch element, and superscripted by the interval of the highest stable pitch element (always with respect to the lowest one).

One of the advantages of the type of representation shown in Fig. 8 is that it is automatically adapting to any tuning system used. The display of the "active" stable pitch elements by vertically moving bars (one for each voice) in the right part of the display window is closely related to chironomic choir singing which is a very intuitive teaching practice, see D'Alessandro et al. (2014). "Understanding" the structure of a song from such a representation does not require the ability to read sheet music, which is yet another advantage.

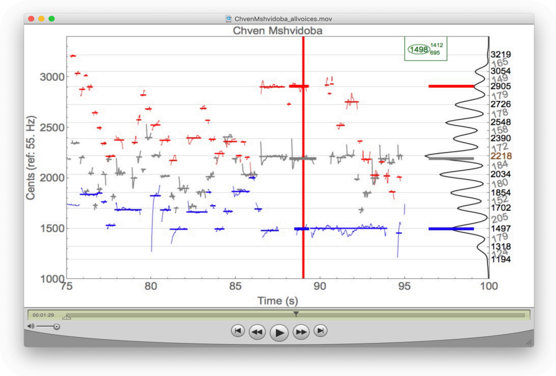


Figure 8: Screen dump of the "pitch track movie" for the song "Chven Mshvidoba". The red vertical cursor marks the audio playback position.

5. DISCUSSION AND OUTLOOK

In recent years, we have seen a revolution in how computer technology changes the way we live and interact with the world around us. Not surprisingly, these changes have also started to influence ethnomusicology and have led to the emergence of the new research field of Computational Ethnomusicology. The success of computational analysis, however, strongly depends on the availability and quality of data. With the new collection of recordings presented here, a high-quality multi-media data set is now available for the first time with which computational analysis of traditional Georgian vocal music can systematically be performed on a larger scale.

The multi-media nature of the new corpus, the unconventional recording strategy (using larynx microphones in addition to conventional audio recordings), together with the unique web-based interface, now enables researchers to

[4] https://www.uni-potsdam.de/fileadmin01/projects/soundscapelab/Videos/ChvenMshvidoba_allvoices.m4v

address a multitude of research questions related to problems such as pitch tracking, harmonic and melodic analysis, and the analysis of the interaction of singers, in completely new ways. In addition, classical ethnomusicological analysis can benefit as well from these corpora by the easy access to the multi-media recordings and the collected metadata.

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