

Overview

Kaleidoscope is a collection of tools for the efficient processing of acoustic and ultrasonic recordings. Some of these tools are licensed separately.

In a single batch operation, Kaleidoscope can perform several tasks in parallel:

- [Convert audio file formats](#)
 - *.wac* Wildlife Acoustics compressed format
 - *.wav* Waveform Audio File Format
 - *.??#* AnaLookW zero crossing sequence file format
 - Support for both time-expanded and normal speed files
 - Support for breaking large files into smaller pieces
 - Support for splitting multi-channel recordings into multiple single channel recordings
- [Add field notes](#) to meta data in output files
- [Filter out files](#) containing only "noise"
- [Extract GPS tracks](#) from metadata
- [Automatic identification](#) of files to species
- Generate files suitable for creating pivot table reports

In addition, with [Kaleidoscope Viewer](#), you can:

- View spectrograms by opening individual full spectrum or zero crossing files
- Add or edit meta data (e.g. field notes and manual classifications) to files
- Quickly review and manually verify automatic identifications

Kaleidoscope retains most of its settings and writes them to a file "settings.ini" in the output directory. You can load a settings file or restore default settings from the "File" menu.

File Conversion

Kaleidoscope can convert a batch of input files recorded in a variety of input formats to output files in a variety of output formats. This feature is available at no charge.

File Types

.*wac* Wildlife Acoustics Compressed Format

The *.wac* or Wildlife Acoustics Audio Compression format is a proprietary audio format produced by Song Meter and Echo Meter recorders. A *.wac* file may contain one or more channels (mono or stereo recordings), and these recordings may be either continuous or triggered. Triggered recordings are used for ultrasonic work (e.g. recording bats) where only periods of detected activity (a triggered event or "bat pass") are recorded. A triggered *.wac* file may contain several triggered events as they are detected independently on each channel. In addition to acoustic data, *.wac* files may contain GPS track information when created by GPS-enabled recorders.

.*wav* Waveform Audio File Format

The *.wav* format is a defacto standard developed by IBM and Microsoft for representing multi-channel audio recordings. There are several flavors of *.wav* file formats that may utilize different forms of audio compression and meta data. Kaleidoscope supports only uncompressed 8-bit and 16-bit Pulse Code Modulation (PCM) *.wav* files. Wildlife Acoustics has also defined a proprietary extension to the *.wav* file format to store metadata.

Time Expanded Files:

The *.wav* format described above may also represent time expanded recordings. Time expanded recordings are commonly used in ultrasonic work where the original recording is stretched through time by a constant factor effectively slowing it down such that ultrasonic signals are divided down into the audible range. This is accomplished by simply adjusting the sample rate of the recording. For example, if a recording is made at 384,000 samples per second, the sample rate in the file's metadata can be changed to 38,400 while keeping all the original audio samples. If we now play back this file at 38,400 samples

per second, it will take ten times longer to play and the frequencies will have been divided down by a factor of ten times. Such a file would be said to have a time expansion factor of 10.

.??# AnalookW Zero Crossing Sequence File Format

The .??# format is a proprietary format used in legacy zero-crossing bat detectors developed in the early 1990s by Chris Corben for Titley Electronics. These are not "recordings" in the conventional sense in that the original analog signal was not digitized and saved like they are in *.wac* and *.wav* files. Instead, the time between a number (division ratio) of sequential zero crossings is stored in the file. The original signal can not be reconstructed from this small amount of data. However, with sufficient signal-to-noise ratio, the dominant frequency sweep through time produced by the echolocation calls of bats can be represented.

Batch File Conversion

Choose the input files you wish to convert:

From the "Batch" tab on the Kaleidoscope main window, set the "INPUTS" parameters found on the left hand side of the window:

1. Choose your "Input directory", a folder on your computer containing the input files you wish to convert.
2. Check "Include subdirectories" if you want to convert files recursively in all the subfolders below the "Input directory" specified above. Otherwise only the files found in the "Input directory" will be converted and subfolders will be ignored.
3. Check "WAC files" if you want to convert from *.wac* files.
4. Check "WAV files" if you want to convert from *.wav* files. You must also select the "Time expansion factor" used by the input files. A factor of "1" should be used for normal speed files. If the input *.wav* file was created by a time expansion bat detector, the time expansion factor should be set to the time expansion factor used to make the recording.
5. Check "ZC files" if you want to convert from *.??#* files.

Choose the output formats you wish to convert to:

From the "Batch" tab on the Kaleidoscope main window, set the "OUTPUTS" parameters found on the right hand side of the window:

1. Choose the output directory in which you want to write the output files. Note that this must not be under the input directory. If the input "Include subdirectories" is checked, output subfolders will be created mirroring the directory structure of the inputs.
2. You can optionally have Kaleidoscope arrange outputs into daily or nightly subfolders (if Kaleidoscope can determine the recording timestamp from the input filenames or metadata) by choosing "Daily" or "Nightly" for "Create subdirectories" Otherwise, you can specify "None".
3. If you would like Kaleidoscope to break up long files into multiple short files, you can specify a value for "Split to max duration", otherwise leave this field blank.
4. Check "WAV files" if you wish to convert to *.wav* files. Check "Split channels" if you would like to separate each channel of a multi-channel input file into individual single-channel output files. If you want to output time expanded files, you can specify a time expansion factor. For normal time files, use a factor of "1".
5. Check "ZC files" if you wish to convert to *.??#* files. You can specify the "Division Ratio" to use. You can also check the "8.3 file names" to output files with the legacy 8.3 filename convention.

Caveats

There are a number of important caveats to keep in mind:

1. Converting from *.??#* zero crossing formats to *.wav* full spectrum formats is not possible to do accurately because zero crossing formats do not contain any amplitude or harmonic content information from the original recorded signal. Instead, Kaleidoscope uses sophisticated digital signal processing techniques to synthesize a full spectrum signal from the zero crossing data that simulates the frequency modulated signal through time, but with no harmonic structure and with uniform amplitude information.
2. Converting from *.??#* to *.??#* produces a copy of the original file and does not actually change the division ratio or split the recording into smaller pieces.
3. The *.??#* file format has a number of file size and duration limitations that are enforced. If converting from a longer *.wav* or *.wac* file, multiple *.??#* files may be produced to avoid exceeding these limits (15 second duration or 32KB filesize or 16K zero crossing points).

4. Converting from `.wav` or `.wac` full spectrum to `00#` zero crossing may use Kaleidoscope's "Advanced signal enhancement" feature (recommended) which can be turned on or off from the "Filter" tab of the main Kaleidoscope window. When turned off, the full spectrum input is band-pass filtered according to the frequency range specified by the "Signal of interest" described in the "Filter" tab and the resulting signal is converted to zero crossing without further enhancement. When turned on, Kaleidoscope further enhances the signal with noise reduction and echo cancellation techniques prior to zero crossing, but also removes echoes and fragmented calls. The result is a cleaner filtered zero crossing output that may detect weak signals that would have been missed or fragmented using conventional zero crossing. On the other hand, some weaker or fragmented pulses remaining may be discarded. We recommend leaving this feature turned on, especially when using the automatic classification features.

Running the batch

Press the "Process files" button to run your batch. A progress bar will display estimated time remaining.

Keep in mind that Kaleidoscope may be performing other tasks in parallel with file conversion such as filtering, GPS track extraction and automatic classification. You should familiarize yourself with these features as they may affect the outputs.

File Naming Conventions

The Song Meter line of products use the following naming convention:

```
Prefix_ YYYYMMDD_hhmmss . extension
```

A "Prefix" may be optionally specified in the Song Meter configuration (typically to keep track of files from different Song Meters with different prefixes). If present, the prefix is prepended to the filename with an underscore character between the prefix and the year. The extension is either "wav" for a WAV file, "wac" for a WAC file, or "00#" for a Zero crossing file.

On the Echo Meter EM3, the file name convention is slightly different to accommodate an additional optional tag character (represented by "T" below). This may be included if one of the tag buttons (e.g. A, B, C, or D) is pressed during recording, or the special "N"

tag used to mark potential noise files. If no tag is present and the file is not a noise file, then the tag character is an underscore. The file name looks like this:

```
Prefix_ T_YYYYMMDD_hhmmss . extension
```

The output file name format will be in one of the following formats:

```
Prefix_   YYYYMMDD_hhmmss_mmm . extension
```

```
Prefix_ T_YYYYMMDD_hhmmss_mmm . extension
```

```
Prefix_ C_YYYYMMDD_hhmmss_mmm . extension
```

If an Echo Meter tag is specified, the second form is used with "T" representing the tag

If splitting channels from stereo to two mono channels, the third form is used with "C" representing the channel number (0 = left, 1 = right).

Otherwise the first form is used. In all these forms, an additional mmm is appended indicating the milliseconds offset.

When converting files that are not in the Song Meter filename format, the original filename is preserved and appended with _C_ssss_mmm . extension.

Filtering Noise Files

During batch [file conversion](#), Kaleidoscope can analyze each output file looking for biological activity of interest and removing files containing only uninteresting signals such as ambient background noise, rain and wind, or unwanted biological signals such as insects when trying to record bats.

Kaleidoscope looks for syllables of smooth continuous narrowband frequency sweeps characteristic of many forms of wildlife including bats, birds, and marine mammals. Even broadband vocalizations may contain dominant harmonics that could be described this way.

On the "Filter" tab of the main Kaleidoscope window, there are several parameters used to describe the signal of interest. As files are processed, Kaleidoscope decides if the file meets the criterion specified:

1. Check "Filter noise files" to enable filtering. Otherwise filtering will not be performed and all output files will be created regardless of content.
2. Check "Keep noise files" if you wish to detect noise files but keep them around for manual inspection. If this is checked, a "NOISE" subfolder will be created and all of the files considered to be noise will be moved into the subfolder. Otherwise, the files will simply be erased from the outputs.
3. Describe the "Signal of interest" by specifying a range of frequencies and durations of continuous smooth narrowband signals and a minimum number of such occurrences that must be found in a given file. If the criteria is not met, then the file is marked as noise and either discarded or moved to the "NOISE" subfolder as configured above.

Useful tip: weak signals may cause a discontinuity in a detected syllable resulting in two or more smaller fragments. You may want to use smaller values for the minimum signal duration in order to consider these weaker signals as "interesting".

The "Advanced signal enhancement" checkbox should generally be enabled and relates to conversion from full spectrum to zero crossing and for the auto classification of full spectrum recordings.

Extracting GPS Tracks

During batch [file conversion](#), the GPS track can be extracted from meta data found in the input files. To enable this feature, you can go to the "GPS" tab of the main Kaleidoscope window:

Extract GPS Track

If checked, the GPS information from input WAC and ZC files is used to generate a gps.csv or gps.kml file (according to the format). An entry is created for each trigger and, in addition, waypoints are created at the specified frequency.

Format

Specify CSV or KML format for gps information. In CSV format, columns are created for DATE, TIME, LAT, LON, and NAME where NAME is the filename of the corresponding output file or blank for waypoints. KML files can be opened directly from Google Earth and have a placemark corresponding to each output file plus a path of waypoints.

Waypoint frequency

Specify the frequency of waypoint output in seconds.

Meta Data

Meta data are bits of information embedded in an audio files that might be useful in the interpretation of the recordings. For example, meta data might describe the location, habitat, weather, and deployment details for a given recording session.

Kaleidoscope enables the use of meta data embedded in audio files. For *.wav* files, Wildlife Acoustics defines a proprietary extension in which to store meta data. For *.??#* files, there are a number of fields defined for this purpose.

Kaleidoscope Meta Data

Kaleidoscope makes use of the following meta data fields:

Voice note

An embedded audio notation such as those created by the Echo Meter Touch. The icon button  will appear if a voice note is present, and clicking the button will play the voice note recording.

Prefix

The user-defined file prefix.

Model

The recorder model name.

Timestamp

The date and time a recording was made.

GPS Location

If a GPS receiver was attached to the recorder, the GPS coordinates corresponding to where the recording was made may be available.

Notes

Field notes created, edited and viewed by humans that could be used to describe the field and deployment conditions in great detail.

Auto Identification Results

The automatic identification made to species by Kaleidoscope

Manual Identification Results

The manually verified identification made to species by a human expert.

Mapping AnalookW Meta Data to Kaleidoscope

For .??# files manipulated by AnalookW software, there are several meta data fields mapped to and from Kaleidoscope meta data fields as follows:

AnalookW Meta Data	Kaleidoscope Meta Data	Additional Comments
Tape	Notes	A line in the Notes field that begins with "Tape: "
Loc	Notes	A line in the Notes field that begins with "Location: "
Spec	Notes	A line in the Notes field that begins with "Spec: "
Notes	Notes	Additional lines in the Notes field
Filetime	Timestamp	
Lat, Lon	GPS Location	
Species	Automatic Identification Results and Manual Identification Results	The "Species" field in AnalookW is formatted as "AUTOID (Kaleidoscope AUTOID,STATS)" or "MANUALID !(Kaleidoscope AUTOID,STATS)" where AUTOID is the automatic classification, MANUALID is the manually verified classification, and STATS are Kaleidoscope statistics.

Adding Field Notes to Output Files

During batch [file conversion](#), Kaleidoscope can replace, append, or prepend field notes to the meta data in output files. On the "Batch" tab of the main Kaleidoscope window at the bottom of the "INPUTS" section on the left, you can select from among "Append notes to output meta data", "Prepend notes to output meta data" or "Replace notes in output meta data" and optionally type field notes into the text box below this choice. When you run the batch job, any notes provided will be added to any existing notes (depending on the choice specified) and written to the output files. Note that the original input files are not modified during batch processing. When outputting to .??# files, lines beginning with "Tape: ", "Location: " and "Spec: " are treated specially with the remainder of the line written to and replacing the corresponding AnalookW fields.

Automatic Identification

You must have a Kaleidoscope Pro license to use the automatic identification feature. Wildlife Acoustics is building classifiers capable of fast and accurate identification to species. At this time, classifiers are offered for bats of North America and the United Kingdom. Not all species are covered, and while our accuracy rates are impressive given the technical challenge, you should not rely solely on automatic classification results to draw conclusions. Our objective is to give you a tool to efficiently analyze a large quantity of data in a short period of time. Wildlife Acoustics hopes to continue expanding classification coverage to include other animals and geographic regions and to improve accuracy.

During batch [file conversion](#), Kaleidoscope can apply classifiers to attempt automatic species identification at the output file level. In fact, it is not necessary to specify any output files in the batch process, but it is recommended to do so for efficient manual review and use of metadata.

To enable automatic classification, go to the "Classifiers" tab on the main Kaleidoscope window, choose your classifier and desired sensitivity level. For best results, choose only those species you expect to find during your deployment.

More information about individual classifiers can be found by clicking on the "About" button shown when you select a classifier.

At the end of batch processing, an "idsummary.csv" and an "id.csv" file will be created at the top of the output directory. A results window containing some of the "id.csv" columns and the Kaleidoscope Viewer will be launched automatically so you can quickly review and update the auto classification results. The spreadsheet table can be saved after editing with "File->Save" or "File->Save As..". You can also re-open this view with Kaleidoscope Viewer from the main Kaleidoscope window with "File->Load results..." to continue work where you left off.

Output Summary File (idsummary.csv)

The "idsummary.csv" file contains an overall summary of the batch classification. At a high level, this file is organized into rows representing output folders (from the input directory hierarchy) and columns representing species-specific data. More specifically, the first N columns represent the output directory structure hierarchy, where N is the maximum folder depth encountered. For example, if the input folder contained three

subfolders A, B, and C, and each of these contained an additional three subfolders X,Y, and Z, we would have a total of 13 possible folder locations. This includes the root of the folder hierarchy, each of the three top level folders, and 9 additional subfolders including A/X, A/Y, A/Z, B/X, B/Y, B/Z, C/X, C/Y and C/Z. The maximum folder depth in this example is two, so the first column represents the first level subdirectories and the second column represents the second level subdirectories. Asterisks are used to denote all the subfolders at a given level. So in this example, we would have the following rows and the first two columns:

Column 1	Column 2	Comments
*	*	Represents overall totals
A	*	Represents totals for folder A and all its subfolders
A	X	Represents totals for files in A/X
A	Y	Represents totals for files in A/Y
A	Z	Represents totals for files in A/Z
B	*	Represents totals for folder B and all its subfolders
B	X	Represents totals for files in B/X
B	Y	Represents totals for files in B/Y
B	Z	Represents totals for files in B/Z
C	*	Represents totals for folder C and all its subfolders
C	X	Represents totals for files in C/X
C	Y	Represents totals for files in C/Y
C	Z	Represents totals for files in C/Z

For each species detected, there is an additional column indicating the number of files found matching the species. There is also a column for "NOID", meaning files that the classifier chose not to classify, and a column for "NOISE", meaning files that were unlikely to be bats. After these columns there is another set of columns for each species detected indicating the calculated presence P-values based on a Maximum Likelihood Estimator (Britzke 2002).

Output Identification File (id.csv)

The "id.csv" file has a row for each output file (excluding "noise" files but including "no identification" files). The columns are as follows:

FOLDER

Directory path to the input file relative to the input root

IN FILE

Input file name

CHANNEL

Channel number from the input file (0=left, 1=right)

OFFSET

Offset in seconds into the input file where output begins

DURATION

Duration in seconds of the output file

OUT FILE

Name of the output file, excluding file type extension.

DATE

Date in form YYYY-MM-DD of the recording

TIME

Time in form of hh:mm:ss of the recording

HOUR

Hour of the recording (0-23) for convenient pivot tables by hour

DATE-12

Date 12 hours prior to date of recording (e.g. for night vs. day) in the form YYYY-MM-DD

TIME-12

Time 12 hours prior to time of recording (e.g. for night vs. day) in the form hh:mm:ss

HOUR-12

Hour 12 hours prior to time of recording (e.g. for night vs. day)

AUTO ID

Automatic classification result

PULSES

Number of pulses detected in the file

MATCHING

Number of pulses matching the auto classification result

MARGIN

Classification margin - this is an uncalibrated confidence score and should not be subject to much interpretation other than that within a given species, higher values are more confident than lower values.

FILES

The number 1, indicating one file, as a convenience for pivot tables by file count

MANUAL ID

Manual identification (this field populated during review with [Kaleidoscope Viewer](#))

Note that this .csv file format is designed for easy import into spreadsheet software to create pivot tables. You can for example create pivot tables to summarize species-specific activity by site, by day, by night, or by hour.