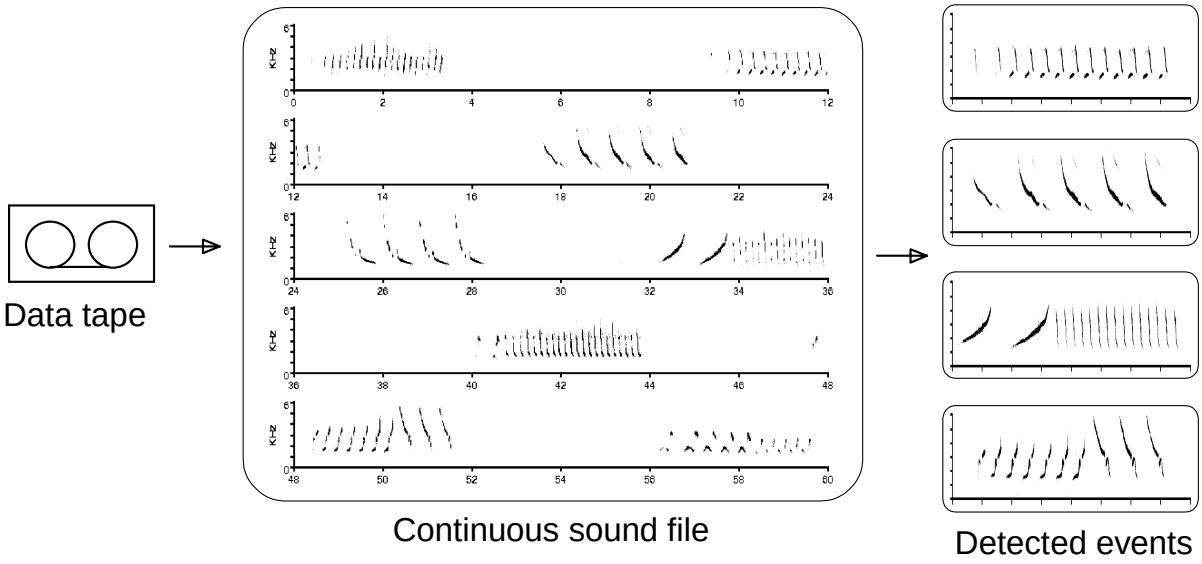
Event Detector™



Automatic analysis of sound files

The Event Detector automatically extracts sound events from an entire sound file according to the user's event specifications. The user digitizes sound data into a continuous sound file, then configures the Event Detector for the events of interest. Detection is based on spectral, temporal, and amplitude criteria. The detector scans the entire file, identifying the desired events and extracting them to individual sound files or measuring their parameters. Detected events can be immediately analyzed in SIGNAL to measure, count, compare, classify, time-stamp, and store sound events and sound parameters. The Event Detector is a module inside SIGNAL and requires SIGNAL to operate. Features include:

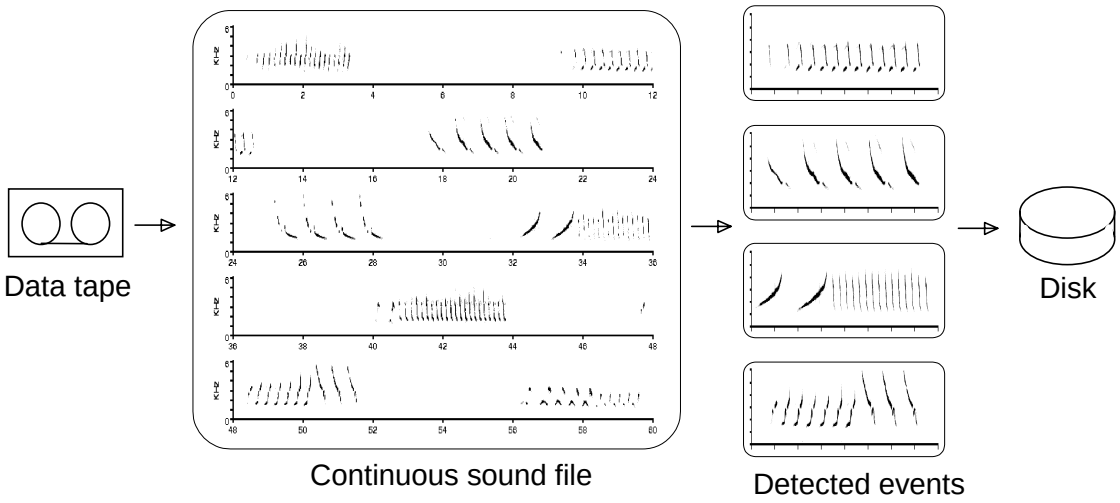
- **Unattended analysis:** Event detection and post-detection analysis can run automatically from a user-written SIGNAL program.
- **Long data sets:** The source sound file can be as large as the hard disk, so many hours of sound can be analyzed in one pass.
- **Handle noisy field data:** A built-in filter significantly reduces background noise and helps exclude non-target sounds from the detection.
- **User-specified detection:** The detector can be flexibly configured for a wide range of sound material, of varying temporal and spectral characteristics.
- **Wide range of user analyses:** Detection can be integrated with user-supplied analysis and measurement of detected events, using SIGNAL analysis tools.
- **Unlimited analysis complexity:** Because the detector analyzes a disk file rather than real-time data, there is no limit on post-detection analysis.

Sample Applications

The Event Detector is part of SIGNAL and can be called from user-written SIGNAL programs. The user can combine event detection with other SIGNAL commands to process the detected events and to automate the entire process. All of SIGNAL's analytical tools are available, providing a wide range of post-detection processing, including sound parameter measurement, editing, feature recognition, sound classification, time-of-occurrence logging, and storing detected sounds and measured sound parameters on disk. Any of these processes can be performed automatically on each detected event. Following are some application examples.

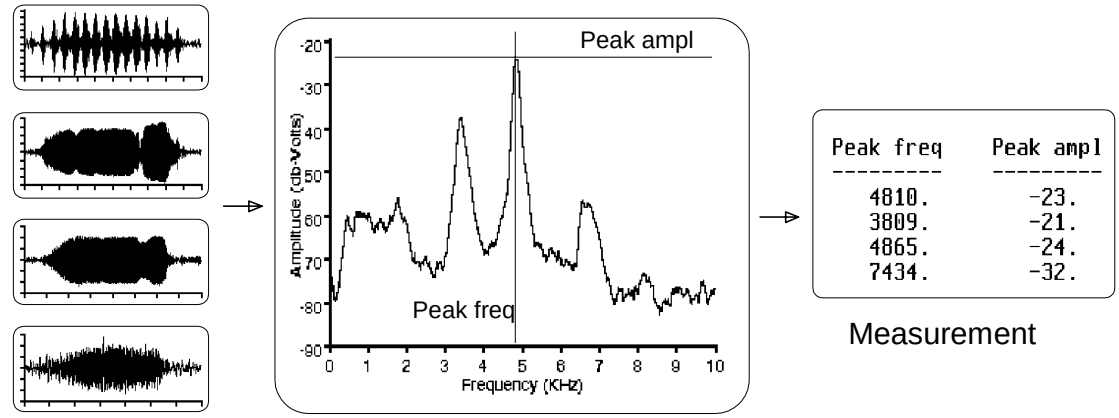
Automatic editing of sound files

The most basic application of the Event Detector is to automatically extract all the target events in a sound file and store them for examination and further processing. This replaces the time-consuming task of manually reviewing large sound data sets and selecting, editing, and storing each event individually. The detector helps achieve uniform event editing by allowing the user to specify pre-event and post-event time margins which extend the detected signal by a fixed interval before and after onset and offset, respectively, so that stored events have consistent amounts of leading and trailing silence.



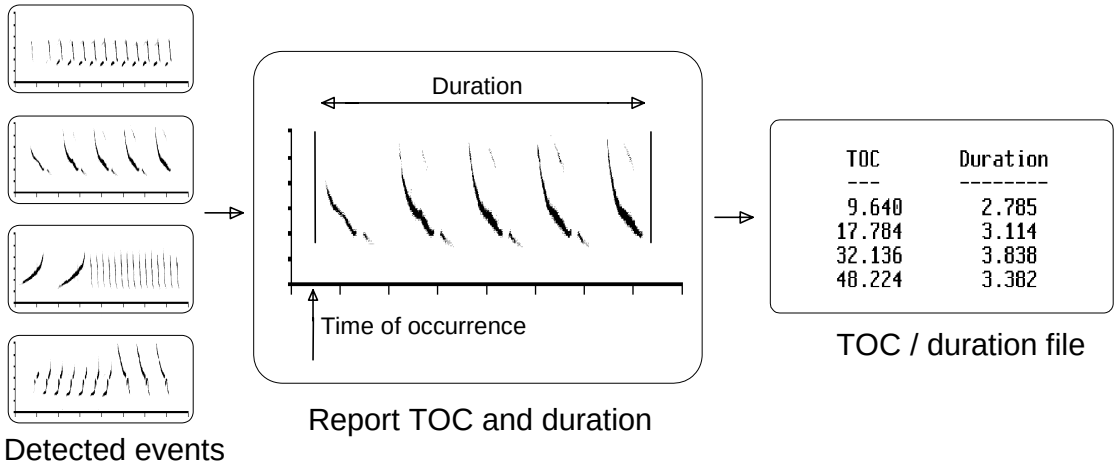
Measuring and storing sound parameters

Another basic application of the Event Detector is sound parameter measurement and storage. Rather than storing the detected sound events, the user's program could automatically measure various sound parameters for each detected event, then store the measurements in a text file for export and analysis. In the following example, SIGNAL calculates the power spectrum of each detected event, then measures and stores the peak frequency and amplitude in a text file.



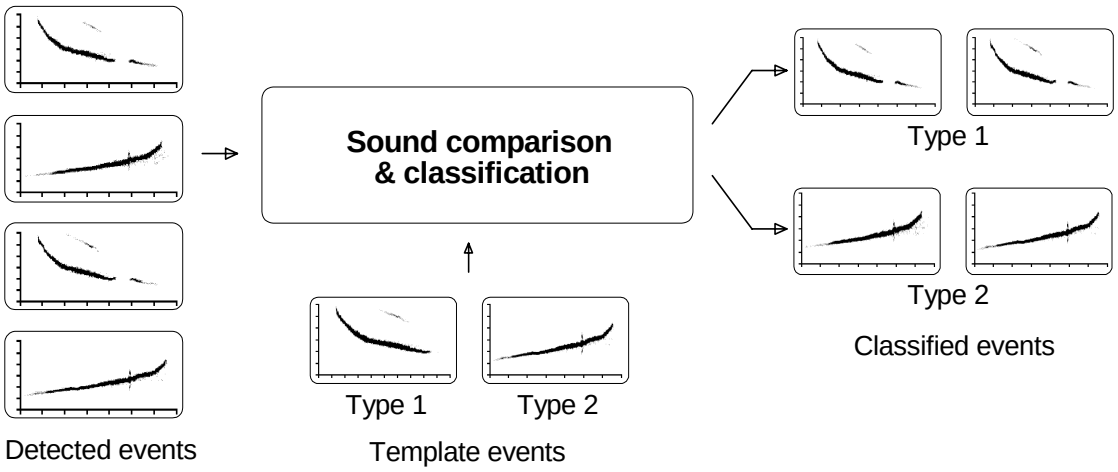
Time of occurrence and sequence analysis

The Event Detector automatically returns the absolute time of occurrence (TOC) and duration of each detected event. Because TOC is based on the source sound file, it can have an accuracy of milliseconds over a time span of hours. This time base can be useful in relating sound events to behavioral observations from other media such as videotape. This long time base also enables the researcher to explore long-term temporal relationships between events anywhere in the file - for example, the order, rate of occurrence, and time spacing of different sound types. This process can be automated by combining the detector with automatic sound type recognition (see below): sound events are detected, classified, their TOC is logged, and sequence relationships are analyzed. In the following example, TOC and duration are stored in a text file for later analysis.



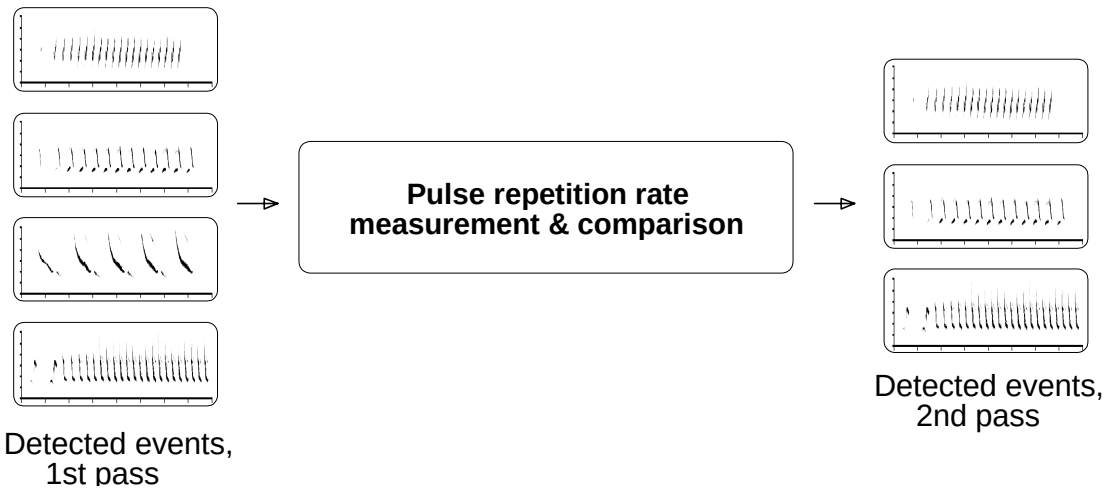
Sound type recognition & classification

Quantitative sound comparison can be applied to the detected events to perform sound type recognition and classification. Events can be compared to a set of pre-stored sound templates for recognition and classification, or to each other, to define and map sound type categories and describe repertoire. Recognition and classification tools include correlations of spectrograms, pitch contours, and spectra, as well as the statistical analysis and comparison of extracted sound parameters.



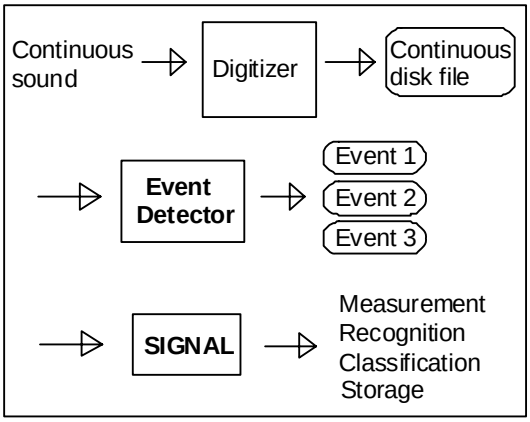
Two-level detection

Two-level detection takes sounds returned by the Event Detector and subjects them to a second round of selection criteria using SIGNAL. This can help detect sounds which are more complicated structurally, or have poorer signal-to-noise, or are acoustically similar to non-target sounds in the environment. The Event Detector parses the data stream into events and non-events, then SIGNAL distinguishes between target and non-target sounds. Second-level criteria can include detailed features such as location of spectral peaks, harmonic density, pitch slope, pulse repetition rate, etc. In the following example, sounds of the desired bandwidth and duration are selected by the Event Detector in the first pass, then target sounds are selected by SIGNAL based on pulse repetition rate.



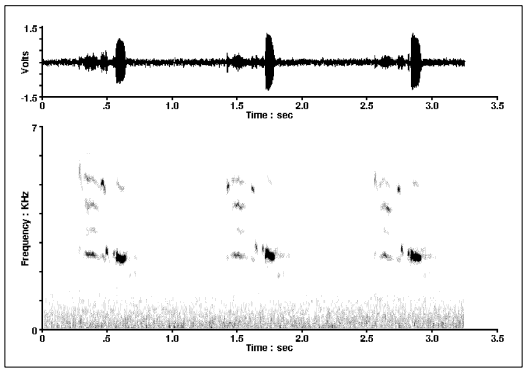
How it Works

The user digitizes extended sound material, which might originate as field data or lab recording, into a continuous sound file.



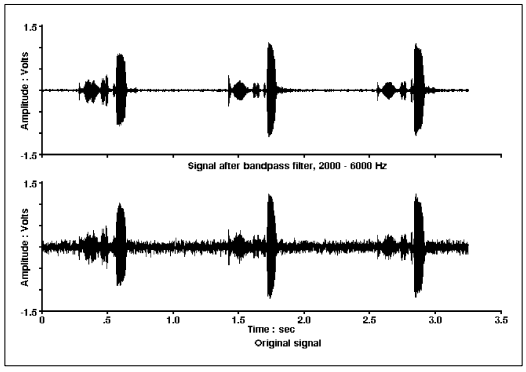
Event detector system

The user then calls the Event Detector to process the entire sound file (step 1), detecting successive events according to user-specified criteria and the detector's logic (steps 2-4). After each event, the detector returns the sampled sound and time-of-occurrence to SIGNAL for analysis, measurement, and storage.



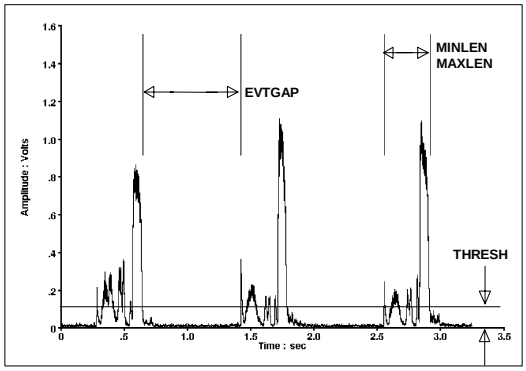
Step 1: three events to be detected

Sound events are detected on the basis of target frequency range (illustrated in step 2), minimum amplitude (step 3), and minimum and maximum event and inter-event duration (steps 3 and 4). These criteria allow the detector to separate sounds from background noise, distinguish target from non-target sounds, and link multiple sub-events (such as notes) into one event (step 4). Detected events are then returned individually to the user (step 5).



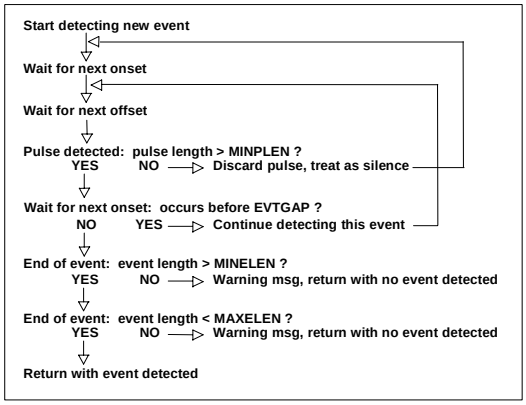
Step 2: effect of target bandwidth

Because the detector is part of SIGNAL, all of SIGNAL's analytical tools are available for post-detection processing. These can be used for sound parameter measurement, editing, feature recognition, classification, time-of-occurrence logging, and disk storage of sounds and measured parameters.



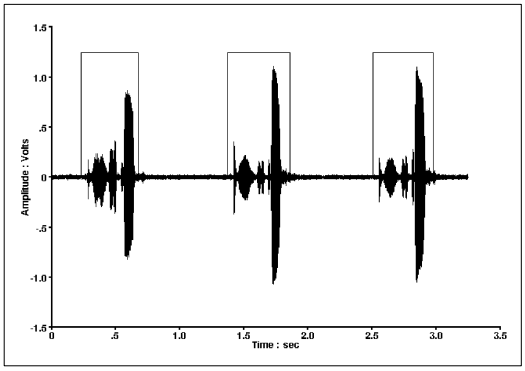
Step 3: time and amplitude criteria

Multiple analyses can be performed on the same source material. For example, one pass might detect all occurrences of a particular sound type and save them as sound files, while another might detect and record the time-of-occurrences of different sound types. The researcher can select a data set and detection paradigm, then run the analysis automatically.



Step 4: detection logic

The detector includes a 35-page User's Guide describing operating principles, detection parameters, programming techniques, a sample session illustrating detector setup, and two operating demos.



Step 5: three detected events

Engineering Design

Berkeley, CA USA Tel 510-524-4476
info@engdes.com www.engdes.com

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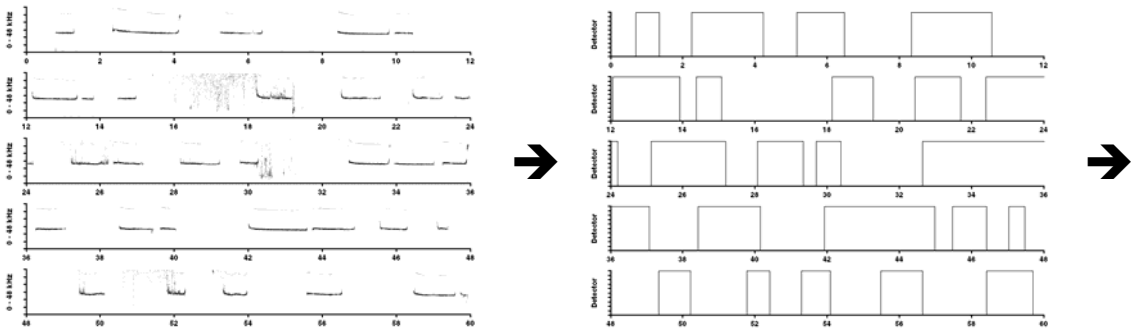
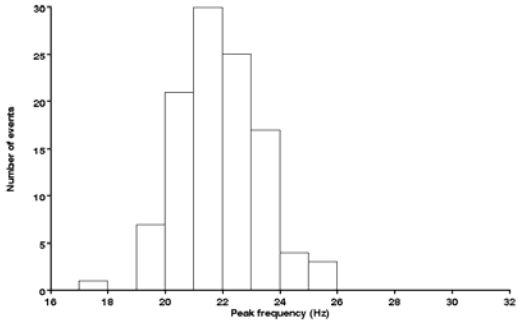
Event Analyzer™



Sound file **Detected sound events**

EVDET 1.0 DATAFILE 4

REC#	TSTART	TINTER	DUR	RMS	FPEAK	FMIN	FMAX
1	0.703	0.703	0.648	0.295	21038	20703	21289
2	2.241	0.890	1.979	0.316	20971	20507	24609
3	5.145	0.925	1.315	0.250	20751	20312	21484
4	8.326	1.867	2.221	0.301	19982	19726	22265
5	12.064	1.517	1.854	0.304	20611	20117	21875
6	14.379	0.461	0.689	0.265	20928	20703	21289
7	18.139	3.071	1.123	0.311	21429	20703	25195
8	20.420	1.158	1.260	0.295	21301	21093	23046
9	22.396	0.716	1.802	0.230	21850	20703	24218
10	25.116	0.918	2.071	0.293	21051	20898	22851
11	28.070	0.882	1.261	0.284	21282	20703	22265
12	29.688	0.357	0.688	0.263	21917	21679	22851



Measured parameters of sound events **Distribution of one parameter**

Automatic event analysis

The SIGNAL **Event Analyzer**™ represents a breakthrough in the analysis of repetitive acoustic events as diverse as field recordings of birdsong, laboratory ultrasonic rodent vocalizations, and industrial monitoring of rotating machinery. It can go automatically from raw acoustic data to summary behavioral acoustic measurements and statistics, such as call rate, call duration, intercall interval, peak frequency, frequency range, etc. Compared to manual event editing and measurement, the Event Analyzer allows the researcher to investigate many more acoustic parameters for significant effects, with a much larger data sample, and, if desired, over a much longer time period.

The Event Analyzer begins with a continuous digitized sound file containing the input audio stream, automatically detects all events of a specified character, measures a suite of event parameters (including time of occurrence, event duration, principal event frequency, and FM frequency range), stores these parameters in a data file, then produces summary statistics and

histogram displays for a variety of parameters over the entire data set. There is virtually no limit on the size of the input sound file, so the analysis period can be very long.

The Event Analyzer automates and integrates the separate processes of event detection, event measurement, and statistical analysis and display. It reduces these processes to a collection of menus, configuration settings, automatic and interactive measurements, diagnostic tools, statistical analyses, and histogram displays, saving the user potentially months of custom programming. Internally, the Event Analyzer utilizes the SIGNAL Event Detector and a variety of SIGNAL analysis tools, and the user must have both SIGNAL and the SIGNAL Event Detector in order to use the Event Analyzer.

Principal features of the Event Analyzer include:

- Automate the event detection process
- Organize detection and analysis settings into configuration menus
- Provide diagnostic tools for visualizing and refining detection
- Optionally save detected events as individual sound files for examination and measurement
- Perform event measurements such as RMS level, peak frequency, and inter-call interval
- Provide both automatic and interactive modes for detection and measurement
- Collect event measurements in a data file for statistical analysis
- Perform statistical analyses such as call rate, time history, and spectral distribution
- Produce histogram displays of event statistics

Event Analyzer applications include:

- Automated measurement and display of statistics such as call rate or peak frequency over large data sets
- Automated editing of continuous sound data into individual sound files
- Efficient development of detection algorithms for different sound types in a data set

How it Works

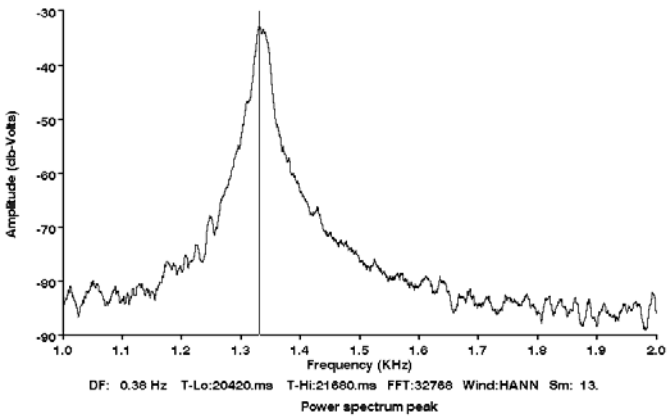
The Event Analyzer consists of two software modules – **EVDET for event detection** and **EVANAL for event analysis**. It requires no additional hardware beyond the ability to record and digitize the input sound file. The program works as follows:

- The user digitizes sound material into an extended sound file, typically using SIGNAL, then configures EVDET for the desired event characteristics.
- EVDET processes the entire sound file automatically, detecting occurrences of the characterized event type and performing measurements on each event.

- EVDET produces an event log file containing event times and measurement results, and optionally saves the detected event as individual SIGNAL sound files.
- EVDET also provides modeling and display tools to visualize and refine detection parameters.
- EVANAL then processes the EVDET output file for statistical analysis and display.
- EVANAL statistics can be individually configured, then selected for screen display or printing.

Examples

Automatic vs. semi-automated mode: The Event Analyzer can be run in two modes. **Automatic** mode detects and measures all events in the input file without user intervention. **Semi-automated** mode allows the user to adjust measurement results, and is useful for monitoring the measurement process and for difficult or noisy source material, on which each detection must be checked and possibly adjusted.



Measuring spectral peak

Event log file: The Event Analyzer measures a number of sound parameters for each detected event, such as time of occurrence, event duration, and peak frequency. These parameters are written to a data file called the **event log file** for later statistical analysis. The log file is normally processed by the Event Analyzer, but it can also be analyzed by a spreadsheet or other statistical program.

EVDET 1.0 DATAFILE 4

REC#	TSTART	TINTER	DUR	RMS	FPEAK	FMIN	FMAX
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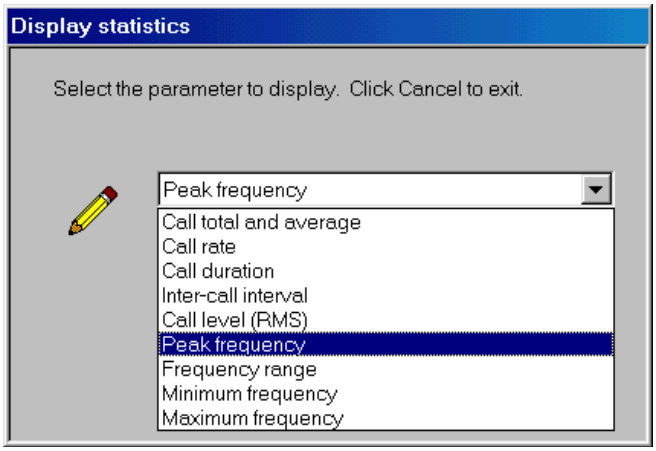
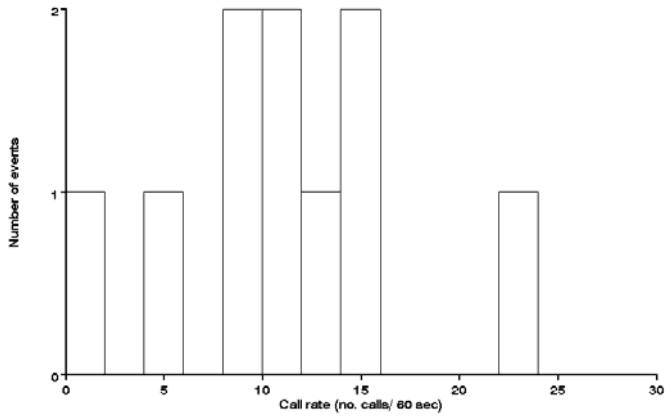
12	29.688	0.357	0.688	0.263	21917	21679	22851

Statistical display: After all events in the input sound file have been detected and measured, the Event Analyzer compiles statistics on each measured input parameter. These parameters include event duration, inter-event interval, RMS level, peak frequency, and frequency range (see figure). The Event Analyzer can then display and/or print a distribution histogram or other display for any of these parameters over the input data set. This is illustrated in the following examples.

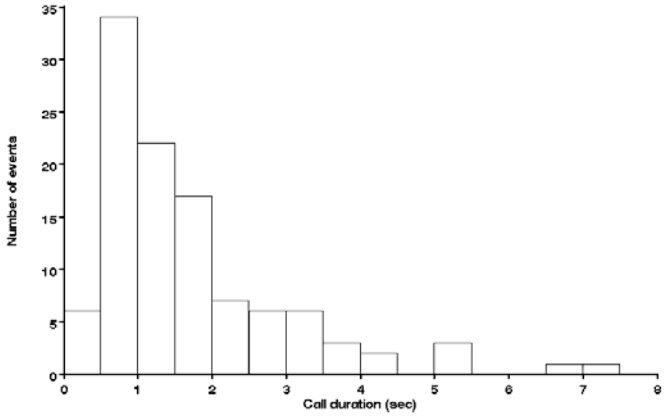


Call rate: Call rate is the number of calls detected within a specified time interval, such as one minute. The data set is partitioned into a sequence of intervals and the number of calls in each interval is counted. The Event Analyzer will display a histogram of call rates and will report the mean call rate.



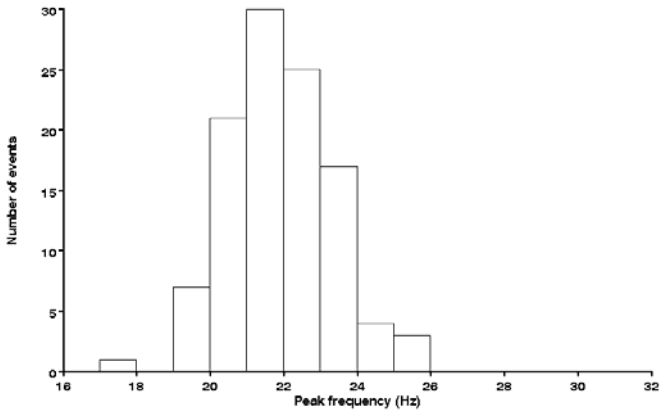
Call rate

Call duration: Call duration is the duration of each event. The Event Analyzer will display a histogram of call durations and report the mean call duration.



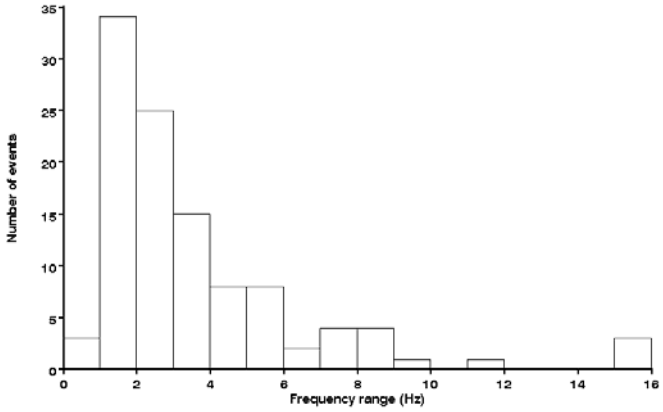
Call duration

Peak frequency: Peak frequency is the frequency value at which the power spectrum of the event achieves its maximum value. The Event Analyzer will display a histogram of peak frequencies and report the mean peak frequency.



Peak frequency

Frequency range: Frequency range is the difference between the minimum and maximum frequencies present above a specified level in the power spectrum of the event. The Event Analyzer will display a histogram of frequency ranges and report the mean frequency range.



Frequency range

Engineering Design

Berkeley, CA USA Tel 510-524-4476
info@engdes.com www.engdes.com

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