Using the AudioMoth Live App with the AudioMoth USB Microphone

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The AudioMoth Live App provides an easy-to-use desktop/laptop app which takes audio from any USB microphone and displays a live scrolling waveform and spectrogram, with options to make continuous recordings, monitor the audio input, or apply a heterodyne bat detector to the input. The app works with all USB microphones but is specifically designed to work with the AudioMoth USB Microphone firmware (AudioMoth-USB-Microphone) that allows all existing AudioMoth hardware versions to be used as configurable USB microphones with a sample rate of up to 384 kHz. It also supports the AudioMoth USB Microphone hardware, which provides a minimal AudioMoth implementation (without an SD card, real-time clock or battery holder) for this use case.

1 AudioMoth Live App

The AudioMoth Live App is an application for Windows, Mac and Linux desktop and laptop computers (and also single-board computers, such as the Raspberry Pi) that displays a live scrolling waveform and spectrogram from a connected USB microphone. It allows the export of image files, continuous and instantaneous capture of WAV files, and includes a monitor and heterodyne bat detector for live listening. It comes in two variants: a desktop/laptop application with a graphical user interface and a command line tool intended to make recordings from USB microphones as easy as possible.

1.1 Graphical User Interface

Figure 1 shows the display of the AudioMoth Live App. As soon as the application is launched, it will look for a connected AudioMoth USB Microphone, connect to this device if found, to the default audio input if not, and start acquiring audio data.

1.1.1 Sample Rate

When the AudioMoth Live App finds a connected AudioMoth USB Microphone it automatically determines the configured hardware sample rate and starts acquiring audio data appropriately. All sample rates equal to the hardware sample rate and below are enabled on the user interface. The selected sample rate is highlighted, and is used to generate the displayed spectrogram, and when writing WAV files.

If an AudioMoth USB Microphone is not connected, the AudioMoth Live App will start acquiring samples from the default audio input at a sample rate of 48 kHz. The default input can be changed with the standard operating system audio control panel, and the sample rate can be switched between 48 kHz and 384 kHz using the ‘Enable High Sample Rate for Default Input’ menu option in the AudioMoth Live App.

1.1.2 Autosave

When autosave is enabled the app will continuously record the captured audio to WAV files. The user interface allows the maximum duration of these files to be specified (either 1, 5, 10 or 60 minutes). The files will close and re-open appropriately if the sample rate is changed, and are updated at the end of each minute (either updating an existing file or creating a new file as appropriate). The files are named and timestamped as per standard AudioMoth recordings.

1.1.3 Display Width

The display width control allows the width of the scrolling waveform and spectrogram to be changed. The extreme right of the waveform and spectrogram represents the current time, and the last 1, 5, 10, 20 or 60 seconds are shown continuously scrolling to the left. The display width can be changed at any time and the last 60 seconds of audio are always available. The display width has no effect on the autosave recordings. Similarly, the display can be paused or cleared at any time without affecting the autosave recordings.

1.1.4 Capture WAV

The ‘Capture WAV‘ button generates a WAV file representing the period of time shown on the scrolling waveform and spectrogram (i.e. the last 1, 5, 10, 20 or 60 seconds). This recording is independent of any

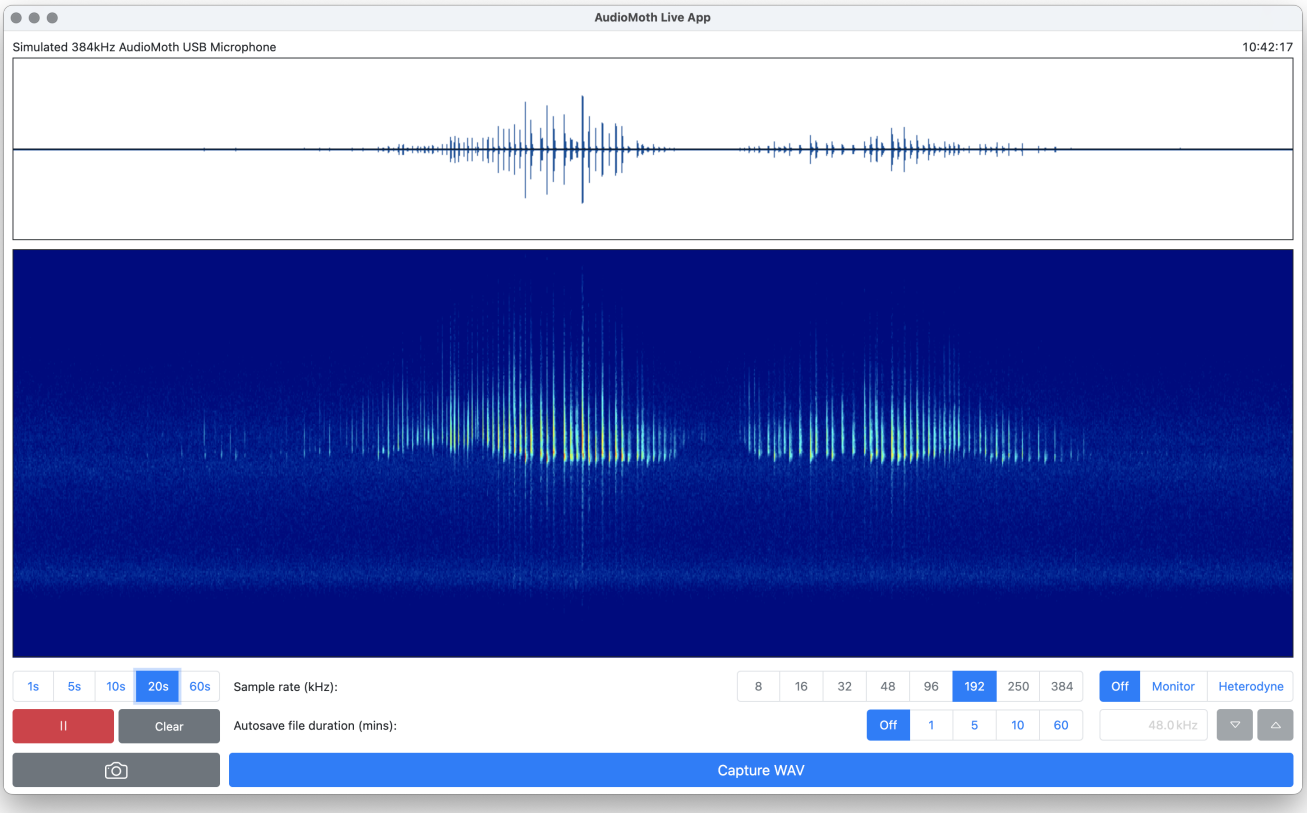

Figure 1: *AudioMoth Live App with the scrolling waveform and spectrogram showing a simulated bat pass (Pipistrellus pipistrellus).*

autosaved recordings being made and allows interesting events to be quickly captured with a single button press after they have occurred.

1.1.5 Export Image

The 'Export Image' button generates and saves PNG, JPG, or PDF images of the current waveform and spectrogram displays. Both displays are paused to allow further image or WAV files to be captured.

1.1.6 Monitor and Heterodyne

The live audio from the USB microphone can be listened to using the 'monitor' option and a heterodyne bat detector can be applied using the 'heterodyne' option. Both options can potentially generate feedback if the microphone is close to the speakers where the audio is playing, and a warning is displayed to this effect. The frequency of the heterodyne bat detector can be varied between 12 kHz and the Nyquist frequency (the sample rate divided by two).

1.1.7 Simulate

To allow the various controls to be explored in real-time, particularly the heterodyne bat detector, the AudioMoth Live App can playback a pre-recorded recording of a common UK bat (Pipistrellus pipistrellus).

1.2 Command Line Tool

As well as the graphical user interface described above, the AudioMoth Live App has an additional variant, named AudioMoth-Live, that can be used as a command line tool. When installed on Mac, Linux or Raspberry Pi[1], the executable is automatically copied to the `/usr/local/bin` directory and can be run from the command line with:

```
> AudioMoth-Live
```

When installed on Windows, the executable location is automatically added to the `Path` variable, and can be run from the command line with:

```
> AudioMoth-Live.exe
```

In both cases, without any other arguments, AudioMoth-Live will report the installed version number and close.

The command can be followed by a number of optional arguments to enable behaviour identical to that provided by the graphical user interface. The

[1] In addition, the Raspberry Pi installer compiles the command line tool from source code.

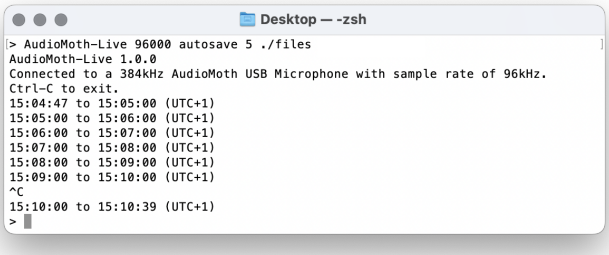

Figure 2: *AudioMoth Live command line tool being used to make five-minute recordings at 96 kHz.*

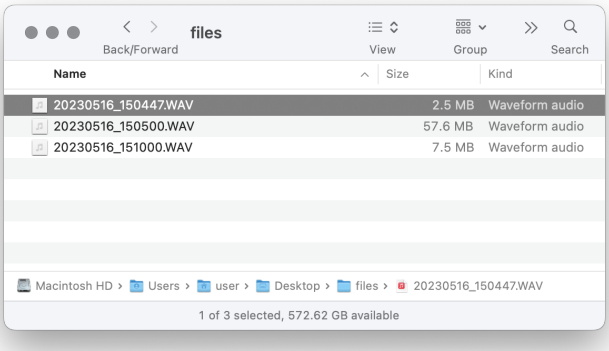

Figure 3: *Resulting WAV files which are 13, 300 and 39 seconds long.*

order of the individual arguments does not matter and they may be in either upper or lower case.

AUTOSAVE enables continuous recording of the captured audio to WAV files. The keyword must be followed by the maximum duration of these files (1, 5, 10 or 60 minutes). For example, the following command saves five-minute WAV files to the current directory.

```
> AudioMoth-Live autosave 5
```

The command line will update at the end of each minute as audio data is written to the current file. If the command line tool is exited by pressing Ctrl-C the current file will be closed.

By default, AudioMoth-Live will use a sample rate of 48 kHz. This can be changed by adding the required sample rate to the list of arguments. Valid sample rates are 8000, 16000, 32000, 48000, 96000, 192000, 250000 and 384000 Hz. The sample rate setting can be used in combination with any of the other optional arguments. For example, to record at 96 kHz, rather than 48 kHz as above, the following command would be used.

```
> AudioMoth-Live 96000 autosave 5
```

Finally, an additional file destination can follow the maximum duration argument. For example, the following command saves five-minute WAV files, with a sample rate of 96 kHz, to a directory called `files`.

```
> AudioMoth-Live 96000 autosave 5 files
```

Figure 2 shows the output when running the command above and Figure 3 shows the resulting files. Note that in this case, the full five-minute recording runs from 15:05:00 to 15:10:00, with truncated recordings of 13 and 39 seconds on either side.

HIGHSAMPLERATE or **HSR** enables high sample rates when using the default audio input. By default, AudioMoth-Live will collect hardware samples from the USB microphone at a sample rate of 48 kHz. Some microphones are capable of providing samples at a faster rate, and this option enables hardware samples at 384 kHz. For example, the command below acquires samples from the USB microphone at 384 kHz and downsamples them to write files at 192 kHz.

```
> AudioMoth-Live 192000 hsr autosave 1
```

UTC switches file names and timestamps from local time to UTC.

```
> AudioMoth-Live autosave 1 utc
```

MONITOR enables the audio monitor, sending the captured audio to the default audio output device. Note that this can cause feedback if the microphone is close to the audio output device. This mode is useful for hydrophones such that underwater sounds are directed to the audio output.

```
> AudioMoth-Live monitor
```

HETERODYNE enables the heterodyne bat detector, sending the output to the default audio output device. The keyword must be followed by the frequency of the heterodyne received in Hertz. This must be greater than 12000 Hz and less than half the sample rate. For example, the command below samples the audio at 192 kHz and applies a 45 kHz heterodyne bat detector.

```
> AudioMoth-Live 192000 heterodyne 45000
```

Note that feedback can occur, but is less likely, as the sound output is generally at a much lower frequency than the heterodyne frequency.

2 AudioMoth USB Microphone Firmware

The AudioMoth Live App is designed to work seamlessly with the AudioMoth USB Microphone firmware. AudioMoth Live will automatically detect the presence of the AudioMoth USB Microphone, connect to it, and set an appropriate hardware sample rate.

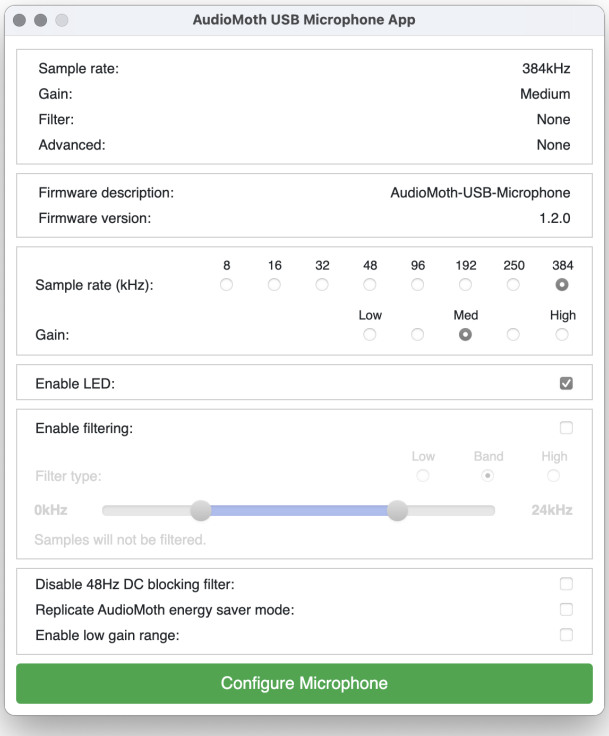

Figure 4: *AudioMoth USB Microphone App showing a configured microphone.*

The AudioMoth USB Microphone firmware can be installed on any AudioMoth device (including µMoth and AudioMoth Dev variants) by downloading it from the AudioMoth Labs website[2], and using the 'Use Local File' option within the AudioMoth Flash App[3]to update the device firmware. When the AudioMoth is now switched to DEFAULT or CUSTOM, it will enumerate as a USB microphone and appear alongside other audio input devices on the computer to which it is connected.

By default, the sample rate of the AudioMoth USB Microphone will be 384 kHz and the medium gain level will be set. However, a range of other options, including additional filters, can be enabled by switching to USB/OFF and using the AudioMoth USB Microphone App (see Figure 4) to configure these settings. The settings are persistent and will be retained by the AudioMoth when powered down.

When in CUSTOM mode, all the configured settings are applied, and the red LED flashes. When in DEFAULT mode, only the configured sample rate and gain are applied, and the green LED flashes.[4] It is possible to switch between DEFAULT and CUSTOM without the USB microphone disconnecting (by moving the switch directly from one position to the other), allowing the effect of different settings to be compared within a single recording. Similarly, external microphones may be plugged in and out, without the USB microphone disconnecting.

3 AudioMoth USB Microphone Hardware

When used as a USB microphone, many of the standard AudioMoth components (such as the battery holder, external 256KB SRAM, SD card, and 32768 Hz real-time clock crystal) are no longer needed. The AudioMoth USB Microphone hardware is an AudioMoth variant with these components removed. It is designed to specifically run the AudioMoth-USB-Microphone firmware (see Figure 5) and uses an identical audio front-end to the AudioMoth 1.2 and AudioMoth Dev variants. It has a permanently mounted 3.5mm jack to support the use of external microphones and hydrophones and measures just 40mm x 35mm. It can be deployed in a custom housing, or in its splash-proof injection moulded housing (see Figure 6) which is fitted with a Gore GAW112 acoustic vent[5].

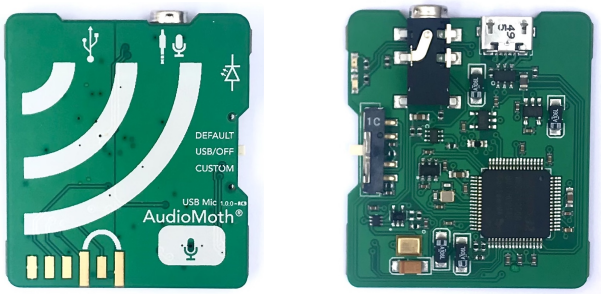

Figure 5: *AudioMoth USB Microphone custom hardware.*

Figure 6: *AudioMoth USB Microphone splash-proof injection moulded housing.*

[2] https://www.openacousticdevices.info/usb-microphone
[3] https://www.openacousticdevices.info/applications
[4] It is possible to disable the LED in both modes using an option in the AudioMoth USB Microphone App.
[5] https://www.gore.com/system/files/2019-09/GORE-Acoustic-Vents-Dust-Splash-EN_0.pdf