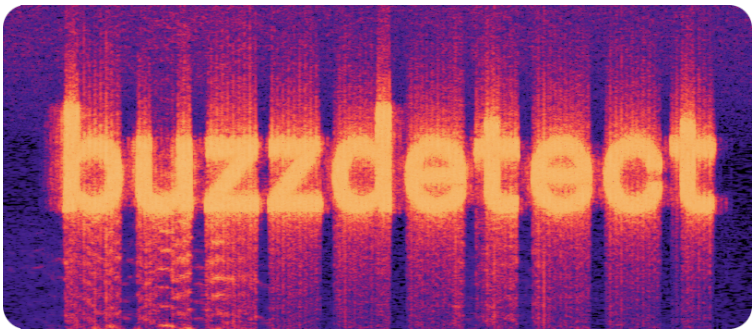
Bioacoustics and Passive Pollinator Monitoring

Instructions

Part 1: Insect sounds in research

For many insect calls, the function is much the same as birdsong - the purpose of the call is to attract others of the same species, essentially broadcasting a species identification through the air! This is very convenient for researchers in the field of bioacoustics, the study of living things by the sounds they make. Researchers have taken advantage of insect calls to study tropical katydids by recording the chorus of night calls and using machine learning to identify the different species present. However, not all insect sounds are so intentional; some insects make sound incidentally. A bee in flight isn't particularly interested in making a buzz, it's simply a consequence of how her wings disturb the air as she flies. But even if the sound doesn't have a function for her, it can still be useful to us!

An introduction to buzzdetect



buzzdetect is a free and open source machine learning tool for passive acoustic monitoring of pollinator activity. In other words, it listens for bees in audio. In this assignment, we'll get hands-on experience using buzzdetect. First, let's see how researchers use passive acoustic monitoring to answer their research questions.

ON YOUR WORKSHEET **QUESTION 1.1**

Read the following article on buzzdetect: https://entomologytoday.org/2026/02/24/buzzdetect-open-source-bioacoustics-listening-pollinators/

Respond to the following questions in a *minimum* of four sentences:

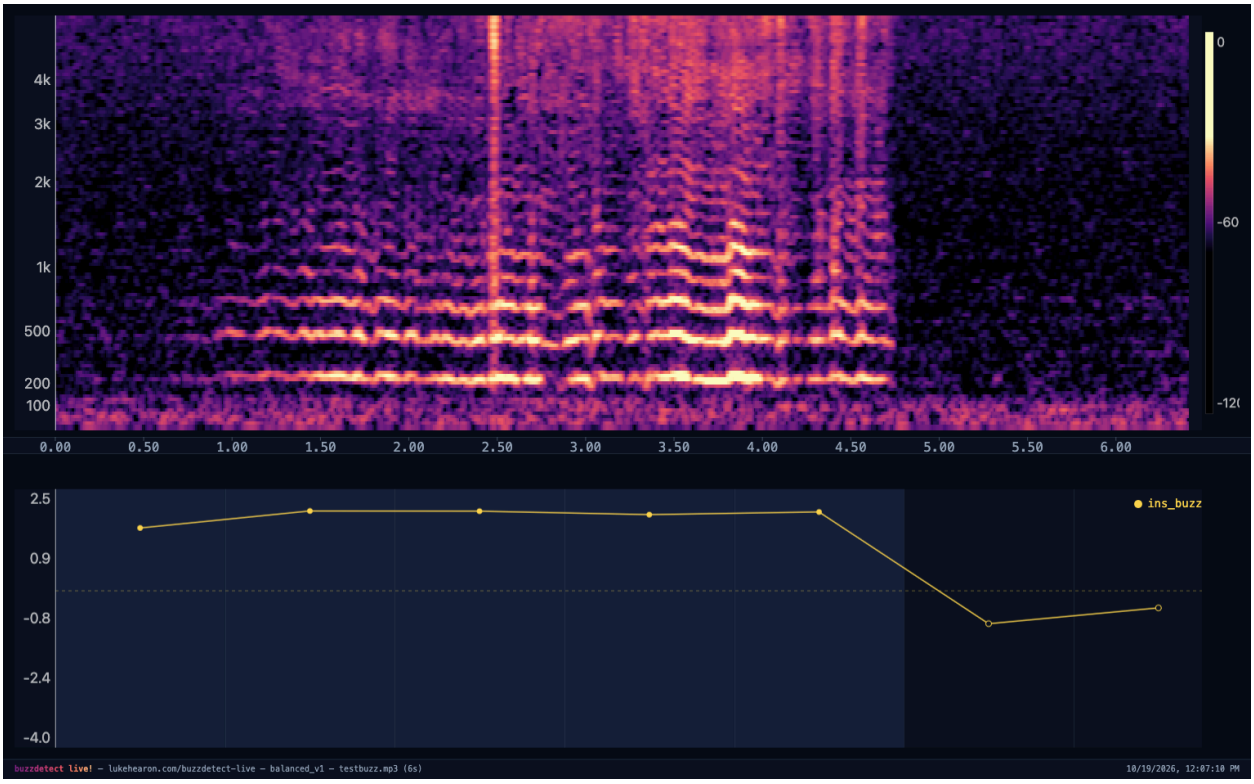
1. Why is passive acoustic monitoring useful? What issue does this solve for researchers?
2. What sorts of research questions can be answered with acoustic bee monitoring?
3. Outside of academic research, how could bioacoustic monitoring tools like this be useful?

Part 2: Running your own analyses

In this section of the lab, we'll be using a lightweight version of buzzdetect called "buzzdetect live!". You can view it here: https://lukehearon.com/buzzdetect-live/

Getting situated

Open buzzdetect live! and follow the walkthrough (the compass icon in the top right) to see how to use the app. The walkthrough will load a recording of a bee buzzing. When you finish the walkthrough, you should see something like this reference screenshot:



That visual at the top is a spectrogram, a heat map of sound. The X axis is time, the duration of the file. The Y axis represents pitch (measured as frequency, Hz) - the higher up you go, the higher the pitch of the sound. The color represents amplitude, the intensity of sound at that time and with that pitch measured in decibels (dB).

A spectrogram like this lets us see what we could otherwise only hear. This is actually how buzzdetect identifies bee buzzes, by analyzing the spectrogram for regions that look like a bee buzz. If you look at enough spectrograms, you'll be able to see bee buzzes, too!

At the bottom of the screenshot are the buzzdetect results for the bee buzzing demo audio file. The value corresponding to insect buzzing is called "ins_buzz", and it's colored yellow. A detection is called when the value is above 0; when this happens, the dot on the line graph is filled in.

Running your own analyses

Now that you're comfortable with the app, let's try analyzing some field recordings. See the five provided audio files, labeled with letters a through e.

ON YOUR WORKSHEET **QUESTION 2.1**

Pick any three of the files, and use the following steps for each to fill out the table on your worksheet:

1. **Load the file** into buzzdetect live!. Either use the open file button in the top bar, or drag-and-drop the file onto the window.
2. **What do you hear?** Press the play button to listen to the file. On your worksheet, describe what you hear. What is this a recording of? How does it differ from the other recordings?
3. **What do you see in the spectrogram?** Now look at the spectrogram. What do you see? How does it correspond to what you heard? It may help to move the slider on the right side of the spectrogram to adjust the visualization.
4. **How did buzzdetect do?** Now look at the buzzdetect results. How did the model do? Did it correctly identify the insect buzzes? If you don't think it identified the bee buzzes, why do you think the results were the way they were? How does it compare to the other files?

Remember! You're looking for places where the *yellow* ins_buzz line crosses 0; the results from the other neurons may be interesting, but they don't show buzz detections.

Part 3: When a model gets it wrong

Automated detection is nifty, but no method is perfect. One of the major risks of passive monitoring is that of **false positives**: when the model incorrectly thinks it hears a bee. Or in other machine learning instances: incorrectly sees a wolf, detects a disease, or identifies credit card fraud. As you can imagine from these examples, false positives can be very consequential.

False positives are particularly nasty when they are **systematic**. Random false positives look like noise in the results and they're easily factored out with more data. Systematic false positives, however, will look like a real trend - and collecting more data will only strengthen the perceived trend. For example, a passing quadcopter drone sounds a bit like a buzzing bee - and it looks a whole lot like one on a spectrogram! If the researcher flies a drone over the site once per week in the evening, it will show up in the buzzdetect results as if the bees were suddenly very interested in the flowers every Tuesday near sundown.

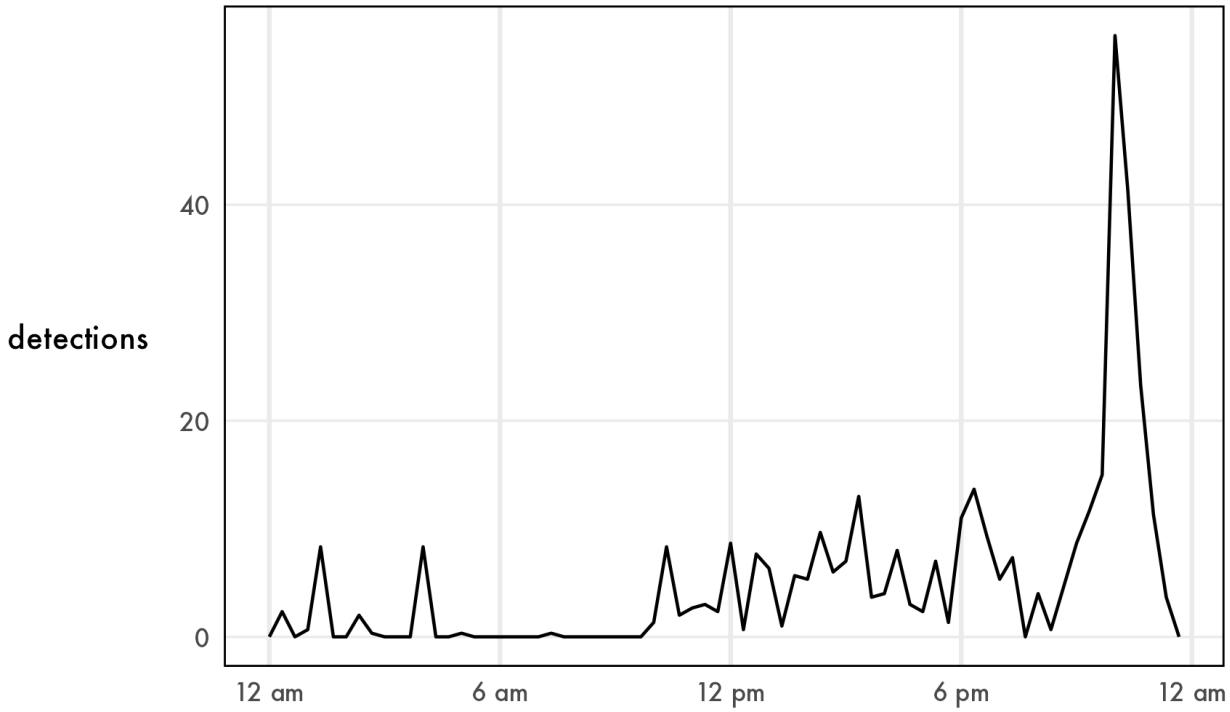


Figure 1: In this analysis of a real experiment using an older buzzdetect model, it appeared that the bees were most active in blueberries right around 10:00pm. This didn't seem very likely, and indeed a second look at the recordings showed that the model was getting confused by passing jet planes.

In this last section, we will try to break buzzdetect. Can you get the model to produce false positives? What types of sounds are prone to producing false positives? Would these be likely to occur in a field recording?

Field recording

In this task, you'll conduct a little bioacoustic research of your own. Can you find real-world audio examples where buzzdetect struggles?

ON YOUR WORKSHEET **QUESTIONS 3.1–3.3**

1. **Identify an outdoor site** to record at. Look for sounds the model might confuse for a bee - a buzzing A/C unit, a passing lawnmower, etc.
2. **Record your audio.** You can either use the live recording function (the red dot icon) built into buzzdetect live! or you can record an audio file first, then pass it through the app. Record at least 1 minute of audio, but more will give you a better chance.
3. **Analyze.** Look at the buzzdetect results and spectrogram. Did the audio produce any false positives? If so, listen to the recording around each false detection. Why do you think the model thought there was a bee here? If there aren't false positives, find the non-buzz audio with the highest ins_buzz score and answer the same questions.
4. **Screenshot.** With the false positives or high scoring non-buzz audio in view, press the camera button in the top right of the app to take a screenshot; attach it to your worksheet.

Buzz like a bee

In this task, you'll try to figure out what the model is looking for when it identifies a bee. These false positives won't be realistic, insofar as they're not going to show up in real field recordings, but they can still tell us a lot about how this technology works.

ON YOUR WORKSHEET **QUESTIONS 3.4–3.7**

1. **Start a recording** on the buzzdetect live! app (note: it works on a laptop or on mobile). As the recording rolls, the spectrogram will fill in and the buzzdetect results will be plotted live.
2. **Make your best imitation of a bee buzz.** Did the ins_buzz line go up? Did it go up enough to produce a detection?
3. **Modulate.** Continue to buzz like a bee, modulating your imitation slowly. What changes the results most? Add a little raspiness or take it away. Buzz higher or lower. What sound gets the strongest result?
4. **Get weird.** Try to make a sound that doesn't sound anything like a bee, but still produces detections. A user was once able to get very strong positives by screaming like a goat. Look at the spectrogram for these positives. Can you see why the model would mistake this for a bee?
5. **Screenshot.** With the false positives in view, press the camera button in the top right of the app to take a screenshot; attach it to your worksheet.
    - Note: it is technically possible to reconstruct the source audio from a screenshot of a spectrogram. Consider submitting this screenshot equivalent to submitting the raw audio - don't say anything you'll regret!