

Submission ID #: 70479

Scriptwriter Name: Poornima G

Project Page Link: <https://review.jove.com/account/file-uploader?src=21496143>

Title: Enhancing an Avian Sound Recognition Model's Detection Precision via Logistic Regression of Large Acoustic Datasets: A Case Study of the European Robin (*Erithacus rubecula*)

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Author Questionnaire

- 1. Microscopy:** Does your protocol require the use of a dissecting or stereomicroscope for performing a complex dissection, microinjection technique, or something similar? **No**

- 2. Software:** Does the part of your protocol being filmed include step-by-step descriptions of software usage? **Yes, all done!**

- 3. Filming location:** Will the filming need to take place in multiple locations? **No**

- 4. Testimonials (optional):** Would you be open to filming two short testimonial statements **live during your JoVE shoot**? These will **not appear in your JoVE video** but may be used in JoVE's promotional materials. **No**

Current Protocol Length

Number of Steps: 25

Number of Shots: 51 (45 SC)

Introduction

Videographer: Obtain headshots for all authors available at the filming location.

Authors: Please note that **the questions will not appear on screen**. Please answer in **stand-alone full sentence with sufficient context**

INTRODUCTION:

~~REQUIRED: Summarize your research focus and the main questions it aims to answer.~~

- 1.1. **Bethany Shackleton:** Our research focuses on developing a reproducible framework to help bioacousticians improve the precision of automated acoustic species detection.
 - 1.1.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera

~~Describe the research gap or limitation in existing methods and how this protocol addresses them.~~

- 1.2. **Bethany Shackleton:** Without proper configuration, avian sound recognition models struggle to accurately detect vocalisations. This protocol improves detection precision by determining species- and site-specific confidence thresholds.
 - 1.2.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera

CONCLUSION:

~~What does this protocol allow researchers to study or measure?~~

- 1.3. **Bethany Shackleton:** This protocol allows researchers to generate accurate detections of target species within large and acoustically diverse datasets.
 - 1.3.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera

~~Describe the most important consideration or challenge when performing this protocol.~~

- 1.4. **Bethany Shackleton:** While this protocol reduces false positives, increasing detection precision, it may also miss some true detections, highlighting a key trade-off with recall.

- 1.4.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera

~~Are there any additional methods or analyses that can be performed following this procedure?~~

- 1.5. **Bethany Shackleton**: Following the production of accurate detections, vocalisations can be annotated within software for parameter extraction and further analysis of acoustic behavior.

- 1.5.1. INTERVIEW: Named talent says the statement above in an interview-style shot, looking slightly off-camera

Videographer: Obtain headshots for all authors available at the filming location.

Ethics Title Card

This research follows the ethical guidelines of Liverpool John Moores University. No animals were handled, disturbed, or experimentally interfered with during data collection

Protocol

***Videographer:** Please always record an audio slate while filming each shot mentioned in the shotlist.*

NOTE: LAB MEDIA/SCREEN timestamps for protocol were added at the postshoot stage. Please contact the postshoot note integrator (Kathyayani Sridharan) for queries regarding lab media.

2. Configuring Autonomous Recording Unit (ARU) for Deployment

Demonstrator: Bethany Shackleton

2.1. To begin, connect each ARU individually to a computer using a data transfer cable [1-TXT].

2.1.1. WIDE: Talent connecting an ARU to a computer using a data transfer cable. **TXT:**
ARU: Autonomous Recording Unit ***Videographer:** Please record a wide shot and then also record a close-up shot for this*

2.2. Use the AudioMoth ARU device configuration application to set the ARUs to determine the sleep intervals [1] and active recording periods [2].

2.2.1. LAB MEDIA: 70479_Screenshot_1: 00:00:00 – 00:00:07

2.2.2. LAB MEDIA: 70479_Screenshot_1: 00:00:08 – 00:00:13

2.3. Identify the time windows when target species are most active and schedule the recording periods accordingly [1]. Add multiple recording periods [2] and schedule the recording dates by choosing the first [3] and last recording dates [4].

2.3.1. LAB MEDIA: 70479_Screenshot_2: 00:00:00 – 00:00:12

2.3.2. LAB MEDIA: 70479_Screenshot_2: 00:00:13 – 00:00:21

2.3.3. LAB MEDIA: 70479_Screenshot_2: 00:00:22 – 00:00:30

2.3.4. LAB MEDIA: 70479_Screenshot_2: 00:00:31 – 00:00:40

2.4. Set an appropriate duty cycle specifying how long the ARUs actively record versus remain in sleep mode [1]. Use the ARU device configuration application to set the devices to record at a sampling rate of 48 kilohertz with medium gain [2].

2.4.1. LAB MEDIA: 70479_Screenshot_3: 00:00:00 – 00:00:03

2.4.2. LAB MEDIA: 70479_Screenshot_3: 00:00:04 – 00:00:14

2.5. Insert each ARU device into an antistatic Ziplock bag [1] and apply additional waterproof tape as needed to prevent water damage [2]. Then, deploy the ARU devices in the field [3].

2.5.1. Talent placing an ARU device into an antistatic Ziplock bag.

2.5.2. Talent sealing the bag and applying waterproof tape around it. Videographer's

Note: Shots 2.5.1 and 2.5.2 were combined together

2.5.3. Talent placing ARU devices at the deployment site.

3. Configure the Machine Learning Detector Module

3.1. Transfer all WAV files from each removable memory card onto a computer [1].

3.1.1. Talent inserting a removable memory card into a computer and transferring WAV files.

3.2. Open the **Raven Pro 1.6** bioacoustics analysis software and select **Tools**, then **Detector**, and choose **Learning Detector** from the drop-down menu [1].

3.2.1. LAB MEDIA: 70479_Screenshot_4: 00:00:00 – 00:00:24

3.3. In the Choose Detector Inputs window, select **Browse** [1]. In the subsequent Open Sound Files window, select all the WAV files within the relevant ARU folder and click **Open** [2]. This will open the **Configure New Sound Window** [3].

3.3.1. LAB MEDIA: 70479_Screenshot_5: 00:00:00 – 00:00:03

3.3.2. LAB MEDIA: 70479_Screenshot_5: 00:00:04 – 00:00:14

3.3.3. LAB MEDIA: 70479_Screenshot_5: 00:00:15 – 00:00:17

3.4. In the **Configure New Sound Window**, under **Paging** and **Page Sound**, enter the appropriate page size for the length of each recording [1]. Then, under **Multiple Files**, select **Open as file sequence in one window** and click **OK** [2]. An Open File Sequence pop-up and Choose Detector Inputs window appears showing addition of selected files to the sequence [3].

3.4.1. LAB MEDIA: 70479_Screenshot_6: 00:00:00 – 00:00:09

3.4.2. LAB MEDIA: 70479_Screenshot_6: 00:00:10 – 00:00:13

3.4.3. LAB MEDIA: 70479_Screenshot_6: 00:00:14 – 00:00:21

3.5. In the returning Choose Detector Inputs window, select **Waveform** under Available Signals and Views and move it to Required Inputs using the arrow button [1]. Confirm that the status under Required Inputs changes to Ready! and click **OK** [2]. This will open the **Configure Machine Learning Detector Window** [3].

3.5.1. LAB MEDIA: 70479_Screenshot_7: 00:00:00 – 00:00:07

3.5.2. LAB MEDIA: 70479_Screenshot_7: 00:00:08 – 00:00:10

3.5.3. LAB MEDIA: 70479_Screenshot_7: 00:00:11 – 00:00:15

3.6. Within the Configure Machine Learning Detector window, under the **Inputs** tab, select the desired model from **Select Model** [1]. Leave the overlap at the default of 0 seconds [2].

3.6.1. LAB MEDIA: 70479_Screenshot_8: 00:00:00 – 00:00:07

3.6.2. LAB MEDIA: 70479_Screenshot_8: 00:00:08 – 00:00:13

3.7. Click on the **Outputs** tab, open the drop-down menu for **Output Class File** and select the output list corresponding to the geographical location of the study [1]. Lower the threshold to 0.1 and select **Apply All** [2]. Ensure that all threshold values in the species list are set to 0.1 [3].

3.7.1. LAB MEDIA: 70479_Screenshot_9: 00:00:00 – 00:00:09

3.7.2. LAB MEDIA: 70479_Screenshot_9: 00:00:10 – 00:00:18

3.7.3. LAB MEDIA: 70479_Screenshot_9: 00:00:19 – 00:00:21

3.8. Now, select the **Suppress All Species** option so that all species are selected [1]. Locate the target species and unselect it in the Suppress column [2].

3.8.1. LAB MEDIA: 70479_Screenshot_10: 00:00:00 – 00:00:03

3.8.2. LAB MEDIA: 70479_Screenshot_10: 00:00:04 – 00:00:24

3.9. Select **OK** to begin the Learning Detector processing [1]. Monitor the Progress Manager to track percentage completed and time remaining [2].

3.9.1. LAB MEDIA: 70479_Screenshot_11: 00:00:00 – 00:00:03

3.9.2. LAB MEDIA: 70479_Screenshot_11: 00:00:04 – 00:00:30

4. Creating Precision Tables for Target Species at a Representative ARU from the Study Location

- 4.1. Open the saved **Learning Detector** selection table and transfer it to spreadsheet software [1]. Confirm that only the target species appears under the Label column [2]. Delete all columns except the Selection and Score columns [3].
 - 4.1.1. LAB MEDIA: 70479_Screenshot_12: 00:00:05 – 00:00:23
 - 4.1.2. LAB MEDIA: 70479_Screenshot_12: 00:00:24 – 00:00:37
 - 4.1.3. LAB MEDIA: 70479_Screenshot_12: 00:00:38 – 00:00:58
- 4.2. Add a new column using the randomisation function [1] and sort the rows based on this column and then delete the randomisation column [2].
 - 4.2.1. LAB MEDIA: 70479_Screenshot_13: 00:00:00 – 00:00:23
 - 4.2.2. LAB MEDIA: 70479_Screenshot_13: 00:00:24 – 00:00:43
- 4.3. Retain the first 300 randomised detections or retain all if fewer than 300 exist [1]. Save the validation dataset using the ARU name and an identifier such as AM1_ValidationDataset.xlsx (*A-M-1 validation dataset*) [2].
 - 4.3.1. LAB MEDIA: 70479_Screenshot_14: 00:00:00 – 00:00:22
 - 4.3.2. LAB MEDIA: 70479_Screenshot_14: 00:00:23 – 00:00:40
- 4.4. Open the **Raven Pro 1.6** bioacoustics analysis software and select **File**, then **Open Sound Files** [1] to select all corresponding WAV files and click **Open** [2]. This will open the Configure New Sound window [3].
 - 4.4.1. LAB MEDIA: 70479_Screenshot_15: 00:00:00 – 00:00:12
 - 4.4.2. LAB MEDIA: 70479_Screenshot_15: 00:00:13 – 00:00:19
 - 4.4.3. LAB MEDIA: 70479_Screenshot_15: 00:00:20 – 00:00:23
- 4.5. In the Configure New Sound window under **Paging**, select **Page Sound** and enter the page size used previously [1]. Next, under **Multiple Files**, select **Open as file sequence in one window** and click **OK** [2]. This will add the selected files to the sequence and

open the spectrogram of each file among multiple selected files [3].

4.5.1. LAB MEDIA: 70479_Screenshot_16: 00:00:00 – 00:00:06

4.5.2. LAB MEDIA: 70479_Screenshot_16: 00:00:07 – 00:00:10

4.5.3. LAB MEDIA: 70479_Screenshot_16: 00:00:11 – 00:00:20

4.6. Navigate to **File** and select **Open Selection Table** to open the Learning Detection Table for the ARU being analysed [1]. In the panel on the left of the sound view under the **Layouts** tab in **Views**, deselect the **Waveform** view so all files display in spectrogram view [2].

4.6.1. LAB MEDIA: 70479_Screenshot_17: 00:00:00 – 00:00:16

4.6.2. LAB MEDIA: 70479_Screenshot_17: 00:00:17 – 00:00:29

5. Precision Calculation and Threshold Optimization

5.1. Open the validation spreadsheet alongside the bioacoustics analysis software with the prepared data [1].

5.1.1. Talent viewing the bioacoustics analysis software and validation spreadsheet side by side on a computer screen.

5.2. Create a new column in the spreadsheet and label it **Correctly Detected** [1].

5.2.1. LAB MEDIA: 70479_Screenshot_18: 00:00:00 – 00:00:12

5.3. From the spreadsheet, select a number from the randomised list and enter it in the **Draw** field within the spectrogram view, then click Play [1]. Enter 1 for correctly detected or 0 (*zero*) for incorrectly detected in the **Correctly Detected** column [2]. Calculate the precision of the detector using the number of correct detections and total validated detections and multiply by 100 to express as a percentage [3].

5.3.1. LAB MEDIA: 70479_Screenshot_19: 00:00:00 – 00:00:25

5.3.2. LAB MEDIA: 70479_Screenshot_19: 00:00:26 – 00:00:32

5.3.3. LAB MEDIA: 70479_Screenshot_19: 00:00:33 – 00:00:48

5.4. Use the software **RStudio** to import the validation dataset created in the previous section [1]. Run a logistic regression on the dataset using the generalized linear modelling function with the family set as binomial [2]. Set the desired probability of precision as 0.9 so that the probability that a detection is a true positive is 90 percent or above [3]. Calculate the optimal threshold by solving the fitted logistic regression equation for the predictor value [4] and verify the obtained threshold value [5].

5.4.1. LAB MEDIA: 70479_Screenshot_20: 00:00:00 – 00:00:05

5.4.2. LAB MEDIA: 70479_Screenshot_20: 00:00:06 – 00:00:18

5.4.3. LAB MEDIA: 70479_Screenshot_20: 00:00:19 – 00:00:26

5.4.4. LAB MEDIA: 70479_Screenshot_20: 00:00:27 – 00:00:38

5.4.5. LAB MEDIA: 70479_Screenshot_20: 00:00:39 – 00:00:45

5.5. Re-run the Learning Detector on the ARU being investigated using the previous detector setup [1], select the sound files [2] enter the **Page size** and select **Open as file sequence in one window** [3]. Next, select Waveform in the Choose Detector Inputs window and move it to **Required Inputs** using the arrow button and click **OK** [4]. Under the **Inputs** tab of **Configure Machine Learning Detector** window, select the desired model and verify that the overlap is set at zero seconds [5].

5.5.1. LAB MEDIA: 70479_Screenshot_21: 00:00:00 – 00:00:10

5.5.2. LAB MEDIA: 70479_Screenshot_21: 00:00:11 – 00:00:20

5.5.3. LAB MEDIA: 70479_Screenshot_21: 00:00:21 – 00:00:35

5.5.4. LAB MEDIA: 70479_Screenshot_21: 00:00:36 – 00:00:40

5.5.5. LAB MEDIA: 70479_Screenshot_21: 00:00:41 – 00:00:50

5.6. Next, in the **Outputs** tab, select the geographical location in the **Output Class File** and change the threshold for the target species to the threshold determined in the previous step and select **Apply All** [1]. Then, select the **Suppress All Species** option, unselect the box for target species and click OK to open the Progress Manager window [2]. Finally, create a new list of detections with improved accuracy and fewer false positives using the optimized threshold value [3].

5.6.1. LAB MEDIA: 70479_Screenshot_21: 00:00:51 – 00:01:04

5.6.2. LAB MEDIA: 70479_Screenshot_21: 00:01:05 – 00:01:31

5.6.3. LAB MEDIA: 70479_Screenshot_22: 00:00:00 – 00:00:20

Results

6. Results

6.1. Representative results from the analysis of acoustic data for the European Robin collected at a park in Liverpool, a naturally regenerating woodland site within The Cairngorms National Park, and a suburban site in Glasgow showed how statistically derived confidence score thresholds [1] improved detection precision across varying acoustic environments [2].

6.1.1. LAB MEDIA: Table 1. *Video editor: Highlight the three rows sequentially: Liverpool Park, Cairngorms, and Glasgow Suburban*

6.1.2. LAB MEDIA: Table 1. *Video editor: Highlight the columns labeled 'Post-regression precision'*

6.2. Logistic regression analysis determined an optimal confidence score threshold of 0.54 for the Liverpool Park site [1] and 0.23 for the Cairngorms site to achieve a precision rate of 90% or higher [2].

6.2.1. LAB MEDIA: Figure 1. *Video editor: Highlight the vertical green dashed line labeled "Threshold = 0.54" on the graph*

6.2.2. LAB MEDIA: Figure 2. *Video editor: Highlight the vertical green dashed line labeled "Threshold = 0.23" on the graph*

6.3. Re-running the detector at the Liverpool Park and Cairngorms sites with the optimized threshold increased detection precision to above 90% for both zero and 2 second overlap conditions [1].

6.3.1. LAB MEDIA: Table 1. *Video editor: Highlight the 'Post-regression precision ol0' AND 'Post-regression precision ol2' for Liverpool Park and Cairngorms rows*

6.4. Re-running the detector at the Glasgow Suburban site with the 0.36 optimized threshold [1] improved detection precision [2] but the overall post-regression precision remained below 90% for both zero and 2 second overlap conditions [2].

6.4.1. LAB MEDIA: Figure 3. *Video editor: Highlight the vertical green dashed line labeled "Threshold = 0.36" on the graph*

6.4.2. LAB MEDIA: Table 1. *Video editor: Highlight the 'Increase in precision ol0' AND 'Increase in precision ol2' for Glasgow Suburban*

6.4.3. LAB MEDIA: Table 1. *Video editor: Highlight the 'Post-regression precision ol0' AND 'Post-regression precision ol2' for Glasgow Suburban*

Pronunciation Guide:

1. Autonomous
Pronunciation link: <https://www.merriam-webster.com/dictionary/autonomous>
IPA: /ɔːˈtɑːnəməs/
Phonetic Spelling: aw·taa·nuh·muhs
2. Configuration
Pronunciation link: <https://www.merriam-webster.com/dictionary/configuration>
IPA: /kənˌfɪɡ.jəˈreɪ.jən/
Phonetic Spelling: kuhn·fig·yuh·ray·shuhn
3. Bioacoustics
Pronunciation link: <https://www.merriam-webster.com/dictionary/bioacoustics>
IPA: /ˌbaɪ.əʊ.əˈkuː.stɪks/
Phonetic Spelling: by·oh·uh·koos·tik
4. Detector
Pronunciation link: <https://www.merriam-webster.com/dictionary/detector>
IPA: /dɪˈtɛk.tə/
Phonetic Spelling: dih·tek·ter
5. Waveform
Pronunciation link: <https://www.merriam-webster.com/dictionary/waveform>
IPA: /ˈweɪv.fɔːrm/
Phonetic Spelling: wayv·form
6. Spectrogram
Pronunciation link: <https://www.merriam-webster.com/dictionary/spectrogram>
IPA: /ˈspek.trəˌgræm/
Phonetic Spelling: spek·truh·gram
7. Randomisation
Pronunciation link: <https://www.merriam-webster.com/dictionary/randomization>
IPA: /ˌræn.də.məˈzeɪ.jən/
Phonetic Spelling: ran·duh·muh·zay·shuhn
8. Logistic
Pronunciation link: <https://www.merriam-webster.com/dictionary/logistic>
IPA: /ləˈdʒɪs.tɪk/
Phonetic Spelling: luh·jis·tik
9. Regression
Pronunciation link: <https://www.merriam-webster.com/dictionary/regression>
IPA: /rɪˈɡreʃ.ən/
Phonetic Spelling: rih·gresh·uhn

10. Generalized
Pronunciation link: <https://www.merriam-webster.com/dictionary/generalized>
IPA: /ˈdʒɛn.ər.əˌlaɪzd/
Phonetic Spelling: jen·uh·ruh·lyzd
11. Binomial
Pronunciation link: <https://www.merriam-webster.com/dictionary/binomial>
IPA: /baɪˈnɒʊ.mi.əl/
Phonetic Spelling: by·noh·mee·uhl
12. Threshold
Pronunciation link: <https://www.merriam-webster.com/dictionary/threshold>
IPA: /ˈθrɛʃ.hoʊld/
Phonetic Spelling: thresh·hohld
13. Kilohertz
Pronunciation link: <https://www.merriam-webster.com/dictionary/kilohertz>
IPA: /ˈkɪl.əˌhɜːts/
Phonetic Spelling: kil·uh·hurts
14. Antistatic
Pronunciation link: <https://www.merriam-webster.com/dictionary/antistatic>
IPA: /ˌæn.tɪˈstæt.ɪk/
Phonetic Spelling: an·tee·stat·ik
15. Waterproof
Pronunciation link: <https://www.merriam-webster.com/dictionary/waterproof>
IPA: /ˈwɔː.təˌpruːf/
Phonetic Spelling: waw·ter·proof
16. Deployment
Pronunciation link: <https://www.merriam-webster.com/dictionary/deployment>
IPA: /dɪˈplɔɪ.mənt/
Phonetic Spelling: dih·ploy·muhnt
17. Validation
Pronunciation link: <https://www.merriam-webster.com/dictionary/validation>
IPA: /ˌvæl.əˈdeɪ.ʃən/
Phonetic Spelling: val·uh·day·shuhn
18. Precision
Pronunciation link: <https://www.merriam-webster.com/dictionary/precision>
IPA: /prɪˈsɪʒ.ən/
Phonetic Spelling: پری·sizh·uhn