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Supplementary material for visualization and categorization of ecological acoustic events based on discriminant features

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1. Algorithm Illustration

The algorithm is formulated with 4 stages, which are briefly described below: (i) in the start, the stage of data pre-processing is define, in this stage the reading of the data, creation of the spectrum and spectrogram image are performed; (ii) after, features are extracted using feature descriptors based on images, spectrum and audio signal; (iii) after that, the stage of analysis of the features is defined to analyze and identify their discrimination capacity to categorize events in the acoustic landscape; to achieve this objective, various visual and numerical approaches would be employed that assisted in the evaluation and determination of the most discriminant features; (iv) finally the stage of visualization of the instances by multidimensional projections, allows the user to visually evaluate the quality of the features reflected in the visual separability between the categories of events. Further details are presented in the Algorithm (1).

Algorithm 1 Algorithm to identify discriminant features.

Input:

data: labeled set of sound files from an acoustic landscape.
model_embedded: Extra Trees Classifier (ETC) model to determine the importance of the features.

model_learn: Random Forest Classifier *RFC*, Support Vector Classifier *SVC*, k-nearest neighbors Classifier *KNNC* ou Extreme Gradient Boosting Classifier *XBGC*.

Output:

$X_{discriminat}$: more discriminant features for a determinate acoustic landscape.

```
1:  $Y \leftarrow \text{Labels}(data)$  // sound file labels
2:  $repeat = True$ 
3: while  $repeat == True$  do
    // Stage (1): pre-processing data
4:  $\hat{X} \leftarrow \text{PreprocessinData}(data)$  //pre-processing of data
    // Stage (2): feature description
5:  $X_{index} \leftarrow \text{IndexFeatureDescription}(\hat{X})$  //acoustic index features
6:  $X_{spectrum} \leftarrow \text{SpectrumFeatureDescription}(\hat{X})$  //spectrum features
7:  $X_{image} \leftarrow \text{ImageFeatureDescription}(\hat{X})$  //spectrogram image features
8:  $X_{raw} \leftarrow (X_{index} \cup X_{spectrum} \cup X_{image})$  //total features
    // Stage (3): discriminant feature analysis
9:  $X_{cleaned} \leftarrow \text{FeatureCleaning}(X_{raw})$  //cleaning features
10:  $X_{normalized} \leftarrow \text{FeatureNormalization}(X_{cleaned})$  //normalization of features
11:  $X_{analyzed} \leftarrow \text{FeatureAnalysis}(X_{normalized})$  //analysis of features
12:  $X_{important} \leftarrow \text{FeatureSelection}(model\_embedded, X_{analyzed})$  //importance of features
13:  $X_{ranking} \leftarrow \text{FeatureRanking}(X_{important})$  //ranking of features
14:  $X_{discriminant} \leftarrow [\emptyset]$  //to store the more discriminant features
15:  $max\_acc \leftarrow 0$  //store value of maximum accuracy
16: for each  $i \in \{0, \dots, |X_{ranking}|\}$  do //for each features of acording to ranking
17:      $X \leftarrow (X_{ranking}^0, \dots, X_{ranking}^i)$  //get be the first n features of the ranking
18:      $acc \leftarrow \text{Learning}(model\_learn, X, Y)$  //train a model and compute test accuracy (acc)
19:     if  $acc > max\_acc$  then //compute the maximum accuracy value
20:          $X_{discriminant} \leftarrow X$ 
21:          $max\_acc \leftarrow acc$ 
22:     end if
23: end for
    // Stage (4): visualization
24:  $view \leftarrow \text{Projection}(X_{discriminant})$  //viusalization the data
25:  $repeat \leftarrow \text{UserVisualEvaluation}(view)$  //the user evaluates the repetition
26: end while
```
