Predicting species identity of bumblebees through analysis of flight buzzing sounds

Supporting information

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The set contains 1 582 features which result from a base of 34 low-level descriptors (LLD) with 34 corresponding delta coefficients appended, and 21 functionals applied to each of these 68 LLD contours (1 428 features). In addition, 19 functionals are applied to the 4 pitch-based LLD and their four delta coefficient contours (152 features). Finally the number of pitch onsets (pseudo syllables) and the total duration of the input are appended (2 features).

The features are saved in Arff format (for WEKA), whereby new instances are appended to an existing file (this is used for batch processing, where openSMILE is repeatedly called to extract features from multiple files to a single feature file). The names and labels of the 34 low-level descriptors, as they appear in the Arff file, are documented in the following list:

Low Level Descriptor (LLD)	OpenSMILE label	Description
Intensity & Loudness	<i>pcm_loudness</i>	The loudness as the normalised intensity raised to a power of 0.3
Cepstrum	<i>mfcc</i>	Vector of 15 MFCCs (0-14).
	<i>logMelFreqBand</i>	Logpower of 8 Mel-frequency bands (0-7) distributed between 0 and 8kHz.
Linear Predictive Coding (LPC)	<i>lspFreq</i>	8 LSP (linear spectral pair) frequencies computed from 8 LPC coefficients.
Pitch	<i>F0final</i>	The smoothed fundamental frequency contour.
	<i>F0finEnv</i>	The envelope of the smoothed fundamental frequency contour.

The low level descriptor data is combined with 21 functionals applied to each of the LLD contours. The names and labels of the functionals as they appear in .arff file are listed below:

Functional type	OpenSMILE label	Description
Extremes	<i>maxPos</i>	The absolute position of the maximum value (in frames).
	<i>minPos</i>	The absolute position of the minimum value (in frames).
Means	<i>amean</i>	The arithmetic mean of the contour.
Regression	<i>linregc1</i>	The slope (m) of a linear approximation of the contour.
	<i>linregc2</i>	The offset (t) of a linear approximation of the contour.
	<i>linregerrA</i>	The linear error computed as the difference of the linear approximation and the actual contour.
	<i>linregerrQ</i>	The quadratic error computed as the difference of the linear

		approximation and the actual contour.
Moments	<i>stddev</i>	The standard deviation of the values of the contour.
	<i>skewness</i>	The skewness (3rd order moment).
	<i>kurtosis</i>	The kurtosis (4th order moment).
Percentiles	<i>quartile1</i>	The 1st quartile (25% percentile).
	<i>quartile2</i>	The 1st quartile (50% percentile).
	<i>quartile3</i>	The 1st quartile (75% percentile).
	<i>iqr1-2</i>	The inter-quartile range: quartile2 – quartile1
	<i>iqr2-3</i>	The inter-quartile range: quartile3 – quartile2
	<i>iqr1-3</i>	The inter-quartile range: quartile3 – quartile1
	<i>percentile1.0</i>	The outlier-robust minimum value of the contour, represented by the 1% percentile.
	<i>percentile99.0</i>	The outlier-robust minimum value of the contour, represented by the 99% percentile.
	<i>pctlrange0-1</i>	The outlier robust signal range »max-min« represented by the range of the 1% and the 99% percentile.
*	<i>sma</i>	The suffix <i>sma</i> appended to the names of the low-level descriptors indicates that they were smoothed by a moving average filter with window length 3.
	<i>de</i>	The suffix <i>de</i> appended to <i>sma</i> suffix indicates that the current feature is a 1st order delta coefficient (differential) of the smoothed low-level descriptor.

Combinations of 100 best LLDs and functional types for our experiment are the following:

@attribute F0finEnv_sma_quartile3 numeric

@attribute F0finEnv_sma_quartile2 numeric

@attribute F0final_sma_quartile3 numeric

@attribute F0finEnv_sma_percentile99.0 numeric
@attribute F0final_sma_percentile99.0 numeric
@attribute F0finEnv_sma_quartile1 numeric
@attribute F0final_sma_quartile2 numeric
@attribute logMelFreqBand_sma[7]_amean numeric
@attribute logMelFreqBand_sma[7]_quartile3 numeric
@attribute logMelFreqBand_sma[7]_quartile2 numeric
@attribute logMelFreqBand_sma[7]_quartile1 numeric
@attribute logMelFreqBand_sma[5]_amean numeric
@attribute logMelFreqBand_sma[6]_quartile2 numeric
@attribute logMelFreqBand_sma[5]_quartile2 numeric
@attribute F0final_sma_de_percentile99.0 numeric
@attribute logMelFreqBand_sma[6]_amean numeric
@attribute logMelFreqBand_sma[6]_quartile3 numeric
@attribute F0finEnv_sma_amean numeric
@attribute logMelFreqBand_sma[4]_quartile3 numeric
@attribute logMelFreqBand_sma[6]_quartile1 numeric
@attribute logMelFreqBand_sma[5]_quartile3 numeric
@attribute logMelFreqBand_sma[7]_percentile1.0 numeric
@attribute logMelFreqBand_sma[5]_quartile1 numeric
@attribute F0final_sma_amean numeric
@attribute logMelFreqBand_sma[4]_amean numeric
@attribute logMelFreqBand_sma[4]_quartile2 numeric
@attribute logMelFreqBand_sma[6]_percentile1.0 numeric
@attribute pcm_fftMag_mfcc_sma[14]_quartile1 numeric
@attribute logMelFreqBand_sma[7]_percentile99.0 numeric
@attribute logMelFreqBand_sma[3]_quartile3 numeric
@attribute pcm_fftMag_mfcc_sma[0]_quartile2 numeric
@attribute pcm_fftMag_mfcc_sma[1]_quartile1 numeric
@attribute pcm_fftMag_mfcc_sma[1]_quartile2 numeric
@attribute logMelFreqBand_sma[7]_linregc2 numeric
@attribute pcm_fftMag_mfcc_sma[14]_quartile2 numeric
@attribute pcm_fftMag_mfcc_sma[1]_amean numeric
@attribute pcm_fftMag_mfcc_sma[0]_amean numeric
@attribute logMelFreqBand_sma[3]_amean numeric
@attribute pcm_fftMag_mfcc_sma[0]_quartile1 numeric
@attribute pcm_fftMag_mfcc_sma[14]_amean numeric
@attribute logMelFreqBand_sma[4]_quartile1 numeric
@attribute F0final_sma_quartile1 numeric
@attribute logMelFreqBand_sma[6]_linregc2 numeric
@attribute logMelFreqBand_sma[2]_quartile2 numeric
@attribute logMelFreqBand_sma[3]_quartile2 numeric
@attribute logMelFreqBand_sma[2]_amean numeric
@attribute logMelFreqBand_sma[5]_linregc2 numeric
@attribute logMelFreqBand_sma[3]_quartile1 numeric
@attribute pcm_fftMag_mfcc_sma[0]_quartile3 numeric
@attribute pcm_fftMag_mfcc_sma[14]_quartile3 numeric
@attribute logMelFreqBand_sma[5]_percentile1.0 numeric
@attribute logMelFreqBand_sma[4]_percentile1.0 numeric
@attribute logMelFreqBand_sma[2]_quartile1 numeric
@attribute F0final_sma_linregc2 numeric
@attribute logMelFreqBand_sma[4]_linregc2 numeric

@attribute logMelFreqBand_sma[3]_percentile1.0 numeric
@attribute pcm_fftMag_mfcc_sma[1]_quartile3 numeric
@attribute logMelFreqBand_sma[4]_percentile99.0 numeric
@attribute pcm_fftMag_mfcc_sma[0]_percentile1.0 numeric
@attribute F0finEnv_sma_linregc2 numeric
@attribute pcm_fftMag_mfcc_sma[1]_percentile1.0 numeric
@attribute logMelFreqBand_sma[2]_quartile3 numeric
@attribute logMelFreqBand_sma[3]_linregc2 numeric
@attribute pcm_fftMag_mfcc_sma[1]_linregc2 numeric
@attribute pcm_fftMag_mfcc_sma[14]_linregc2 numeric
@attribute pcm_fftMag_mfcc_sma[14]_percentile1.0 numeric
@attribute pcm_fftMag_mfcc_sma[3]_amean numeric
@attribute pcm_fftMag_mfcc_sma[3]_quartile2 numeric
@attribute pcm_fftMag_mfcc_sma[0]_linregc2 numeric
@attribute logMelFreqBand_sma[2]_percentile1.0 numeric
@attribute lspFreq_sma[1]_percentile1.0 numeric
@attribute logMelFreqBand_sma[5]_percentile99.0 numeric
@attribute logMelFreqBand_sma[2]_linregc2 numeric
@attribute pcm_fftMag_mfcc_sma[3]_quartile3 numeric
@attribute F0final_sma_de_stddev numeric
@attribute F0final_sma_stddev numeric
@attribute lspFreq_sma[1]_amean numeric
@attribute F0finEnv_sma_de_percentile99.0 numeric
@attribute F0final_sma_linregerrQ numeric
@attribute logMelFreqBand_sma[6]_percentile99.0 numeric
@attribute F0finEnv_sma_de_linregerrQ numeric
@attribute pcm_fftMag_mfcc_sma[13]_quartile1 numeric
@attribute lspFreq_sma[0]_percentile99.0 numeric
@attribute F0finEnv_sma_de_stddev numeric
@attribute logMelFreqBand_sma[1]_percentile1.0 numeric
@attribute lspFreq_sma[0]_quartile3 numeric
@attribute pcm_fftMag_mfcc_sma[3]_quartile1 numeric
@attribute lspFreq_sma[1]_quartile2 numeric
@attribute lspFreq_sma[1]_quartile1 numeric
@attribute F0final_sma_linregerrA numeric
@attribute pcm_fftMag_mfcc_sma[1]_percentile99.0 numeric
@attribute F0finEnv_sma_de_pctlrange0-1 numeric
@attribute pcm_fftMag_mfcc_sma[0]_percentile99.0 numeric
@attribute pcm_fftMag_mfcc_sma[13]_quartile3 numeric
@attribute pcm_fftMag_mfcc_sma[13]_percentile1.0 numeric
@attribute pcm_fftMag_mfcc_sma[14]_percentile99.0 numeric
@attribute pcm_fftMag_mfcc_sma[13]_amean numeric
@attribute logMelFreqBand_sma[3]_percentile99.0 numeric
@attribute pcm_loudness_sma_quartile1 numeric
@attribute pcm_loudness_sma_quartile2 numeric