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CLASSIFICATION AND IDENTIFICATION OF FROG SOUND BASED ON ENTROPY APPROACH

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***Abstract*—A new classification method for animal sound identification using entropy-based approach is proposed. Entropy is a measure of information contents or complexity for a sequence of a signal. This study introduces three definitions of entropy - Shannon entropy, Rènyi entropy and Tsallis entropy, which are used in this paper as the features of extraction for the purpose of the pattern recognition of animal sounds. Sound samples from nine Microhylidae frogs are first segmented into syllables. Then, the features of each syllable are extracted using Shannon entropy, Rènyi entropy and Tsallis entropy. The nonparametric k-th nearest neighbours (k-NN) classifier is then used for frog sound identification system. The result shows that the entropy-based animal sound identification system has successfully identified most of the frog species.**

Keywords-Bioacoustics signal, entropy, frogs sound analysis

I. INTRODUCTION

One of the major tasks when analysing animal sounds is the measuring of acoustically relevant features. There are many features used in bioacoustics analysis, and classifications based on these features are extracted by hand from spectrogram plots [1]. Unfortunately, manual acoustic identification of species is very time consuming and analysis time can be as much as 10 times longer than the recording [2]. In order to speed up the process and likely to lead to the development of continuous real-time monitoring of biodiversity, the development of new identification systems is needed.

Majority of bioacoustics signals analysis and identification systems use time-frequency techniques such as the short-time Fourier transform, wavelets and energy distributions. However, there are several shortcomings occurred, for example, such techniques are computationally intensive and difficult to implement on low cost microcontroller-base system [2].

The purpose of this study is to introduce a new method for animal sound classification based on entropy approach. Shannon entropy, Rényi entropy and Tsallis entropy are used as the features of animal sound. This new classification of animal sound is tested on Microhylidae frogs to assess its performance.

II. THEORETICAL BACKGROUND AND EXPERIMENTAL PROCEDURE

The frog sound classification system proposed in this work basically consists of three processes, namely syllable segmentation, feature extraction and classification.

A. Syllable Segmentation

Each of the single blows of air from frog lung is defined as syllable. The rate of events in frog calls may be high that the segmentation of each syllable is difficult in a natural environment due to reverberation. After segmentation, a set of selected features consists of all the three entropy are measured to represent each syllable.

B. Features Extraction

Three features are extracted from the sound syllables namely Shannon entropy, Rényi entropy and Tsallis entropy. Shannon entropy, $H(X)$ is the measure of information content of a sequence or signal, $X = \{x1, x2, x3, \ldots, xn\}$. Shannon entropy describes the average of all the information contents, I weighted by their probabilities of occurrence p_i, written in mathematical expression as

$$H(X) = E[I(p)] = \sum_{i=1}^{n} p_i I(p) = -\sum_{i=1}^{n} p_i \log_2 (p_i). \quad (1)$$

E[ ] denotes the expectation value.

Shannon entropy can be generalized to quantify the diversity or randomness of a system. This gives the Rényi entropy with the order of order $q \geq 0$, defined as [3]

$$Hq(X) = \frac{1}{1-q}\log_2\left(\sum_i^n p_i^q\right) \quad (2)$$

Rényi information can be used to 'obtain different averaging of probabilities' via the parameter q (see Song, 2001). By considering Hq as a function of q, the spectrum of the Rényi entropy is also of some interest in signal analysis. In this study, $q = 2$ is used for the estimation of Rényi entropy of the frog sound.

The Tsallis entropy (sometimes known as *q*-entropy) is another form of generalization of Shannon entropy. It is written in mathematics expression as [4]

$$s_q = \frac{1}{q-1}\left(1-\sum_{i=1}^{w} p_i^q\right). \quad (3)$$

This equation has been suggested by Tsallis to generalize statistical mechanics using these entropic forms (Tsallis, 1988). $q \in \Re$ is a real parameter and also known entropic index. In this study, Tsallis entropy is introduces as one of the feature to measure signal complexity for frog sound classification. q = 0.1 for the estimation of Tsallis entropy is used in this study.

C. *kth-Nearest Neighbors (k-NN)*

The non parametric *k*-NN classifier is simple yet powerful method for classification in the study of pattern recognition, machine learning, data mining, and information retrieval. Taking an instance *m* with unknown classification, instances with known classification (or the test samples) that are nearer to *m* are given more weights. The similarity between instances is measured by using the distance metric method. In this study, Euclidean distance is selected as the distance metric which defines the distance $d(m,n)$ between instances *m* and *n,* and expressed as [5]

$$d(m,n) = \sqrt{\left(\frac{|y_{m1-n1}|}{R_1}\right)^2 + \left(\frac{|y_{m2-n2}|}{R_2}\right)^2 + \ldots + \left(\frac{|y_{mi-ni}|}{R_i}\right)^2}, \quad (4)$$

where R_a = max (y_a) - min (y_a), which denotes the range of attribute *a* and used as normalization in order to avoid any attribute overpower to the other attributes.

III. EXPERIMENTAL RESULTS AND DISCUSSIONS

Sound signal from nine frog species found in Australia are used in this experiment to assess the performance of the proposed classification method. The sound signals of these frogs were obtained from Frog Australia Network database at http://www.Frogsaustralia.net.au/frogs, and the species selected are listed in Table 1.

TABLE 1. FROG SPECIES FORM MICROHYLIDAE FAMILY

Family	Scientific name	Common name	No. Syllables
Microhylidae	*Cophixalus bombiens*	Buzzing Nurseryfrog	10
	Cophixalus concinnus	Tapping Nurseryfrog; Elegant Frog; Beautiful Nursery-frog	10
	Cophixalus exiguus	Dainty Nurseryfrog; Scanty Frog	10
	Cophixalus hosmeri	Rattling Nurseryfrog; Hosmer's Frog	10
	Cophixalus infacetus	Creaking Nurseryfrog; Inelegant Frog	10
	Cophixalus monticola	Mountain Nurseryfrog	10
	Cophixalus neglectus	Bellenden Ker Nurseryfrog; Neglected Frog	10
	Cophixalus ornatus	Ornate Nurseryfrog; Ornate Frog	10
	Cophixalus saxatilis	Black Mountain Boulderfrog; Rock Frog	10

Ten segments were extracted from each sound signal which corresponds to 10 syllables from each frog's calls. The entropy of each syllable was determined using the previous equation (Equation (1) - (3)). Table 2, Table 3 and Table 4 shows the values of Shannon, Rényi and Tsallis entropy, respectively, for each syllable of the respective frog species.

TABLE 2 SHANNON ENTROPY OF NINE MICROHYLIDAE FROG SPECIES FOR 10 SYLLABLES EACH SPECIES

Shannon Entropy (Bit)									
No.	*bombiens*	*concinnus*	*exiguus*	*hosmeri*	*infacetus*	*monticola*	*neglectus*	*ornatus*	*saxatilis*
1	8.31	9.08	8.53	9.02	8.99	9.18	8.13	7.36	9.55
2	8.30	9.09	8.69	9.07	9.01	9.16	8.12	7.35	9.50
3	8.35	9.07	8.67	9.06	9.10	9.21	8.11	7.35	9.55
4	8.36	9.12	8.52	9.16	9.03	9.18	8.10	7.36	9.51
5	8.35	8.95	8.65	8.96	8.96	9.07	8.11	7.36	9.53
6	8.36	9.05	8.67	8.89	9.00	9.04	8.11	7.37	9.49
7	8.36	9.08	8.66	9.06	9.00	8.97	8.12	7.35	9.55
8	8.30	9.05	8.71	8.89	8.99	8.97	8.11	7.36	9.51
9	8.32	8.95	8.70	8.96	9.01	9.18	8.14	7.36	9.53
10	8.33	9.09	8.65	9.16	8.96	9.15	8.14	7.37	9.49

TABLE 3 RÉNYI ENTROPY OF NINE MICROHYLIDAE FROG SPECIES FOR 10 SYLLABLES EACH SPECIES

Rényi Entropy (Bit)									
No	*bombiens*	*concinnus*	*exiguus*	*hosmeri*	*infacetus*	*monticola*	*neglectus*	*ornatus*	*saxatilis*
1	8.28	8.96	8.24	8.84	8.86	8.91	8.12	7.36	9.10
2	8.27	8.95	8.41	8.87	8.88	8.90	8.11	7.34	9.00
3	8.33	8.93	8.44	8.91	8.99	8.95	8.09	7.34	9.05
4	8.34	8.99	8.21	9.01	8.90	8.91	8.08	7.36	9.03
5	8.32	8.76	8.39	8.81	8.80	8.79	8.09	7.36	9.05
6	8.34	8.91	8.46	8.73	8.85	8.73	8.09	7.37	8.99
7	8.34	8.96	8.43	8.91	8.86	8.64	8.10	7.34	9.05

8	8.26	8.91	8.42	8.73	8.86	8.67	8.09	7.36	9.03
9	8.29	8.76	8.43	8.81	8.88	8.91	8.13	7.36	9.05
10	8.31	8.95	8.40	9.01	8.80	8.99	8.13	7.37	8.99

TABLE 4 TSALLIS ENTROPY OF NINE MICROHYLIDAE FROG SPECIES FOR 10 SYLLABLES EACH SPECIES

Tsallis Entropy (Bit)									
No	*bombiens*	*concinnus*	*exiguus*	*hosmeri*	*infacetus*	*monticola*	*neglectus*	*ornatus*	*saxatilis*
1	200.02	336.75	261.68	335.51	321.10	382.44	176.52	108.31	584.44
2	199.45	339.84	285.78	346.08	324.30	379.78	175.93	107.69	578.34
3	204.04	335.55	276.38	340.05	340.01	388.36	174.76	107.69	596.08
4	204.61	343.67	261.56	358.73	328.10	383.99	174.17	108.31	578.92
5	203.48	318.56	276.19	316.26	316.64	362.74	174.76	108.31	587.15
6	205.19	331.27	276.49	304.30	324.22	359.36	174.76	108.91	577.56
7	205.19	336.75	274.75	340.05	323.15	348.49	175.34	107.69	596.08
8	198.87	331.27	286.98	304.30	321.10	347.58	174.76	108.31	578.92
9	201.16	318.56	284.78	316.26	324.30	383.97	177.10	108.31	587.15
10	202.32	339.84	276.21	358.73	316.64	355.79	177.10	108.91	577.56

Based on the results from Table 2 – 4, the training data for *k*-NN are then selected by taking the average of the particular feature from each species and then fed into *k*-NN algorithm. To assess the performance of the proposed classification method, Equation (5) is used to evaluate its accuracy.

$$A = \frac{N_c}{N_s} \times 100 \qquad (5)$$

A is the percentage of accuracy, N_c is the number of syllables that are correctly recognized and N_s is the total number of test syllables. Figure 1 shows the performance of the proposed method in terms of percentage of accuracy. It should be noted that the percentage of accuracy above 80% is considered successful.

From Figure 1, it can be seen that seven of the species are successfully identified with 100% accuracy. The proposed method has successfully identified the uniqueness of these species. However, *Cophixalus concinnus* and *Cophixalus hosmeri* are failed to be recognized with only 70% and 40% of accuracy, respectively. This could be explained by referring to Table 2, 3 and 4, where the entropy features from both species are very close to each other. This has made it difficult for the proposed method to correctly identify or differentiate them.

IV. CONCLUSION

In this paper, a new classification method of animal species based on their sound signal is proposed. The proposed method uses entropy of the sound signal as feature that represent the characteristic of the animal species. Three types of entropy which are Shannon, Rényi and Tsallis together with *k*-NN classification technique are used. To assess the performance of the method, nine frog species from Microhylidae family were used as test samples. It was found that in general, the proposed method managed to correctly identify most of the frog species with 100% of accuracy. Only two of the nine frog species are failed to identify which are associated to the resemblance between the entropy values of these species.

V. CONCLUSION

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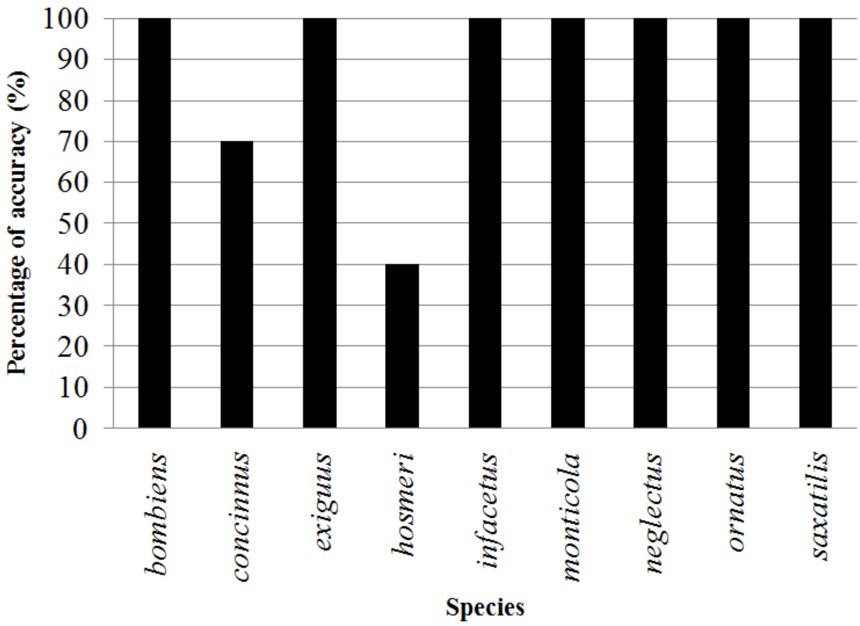

Figure 1. Performance of frog sound classification system by using entropy approach for nine Microhylidae frog species.