Information Theoretic Approach Based on Entropy for Classification of Bioacoustics Signals

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Abstract. A new hybrid method for automated frog sound identification by incorporating entropy and spectral centroid concept is proposed. Entropy has important physical implications as the amount of "disorder" of a system. This study explores the use of various definitions of entropies such as the Shannon entropy, Kolmogorov-Rényi entropy and Tsallis entropy as measure of information contents or complexity for the purpose of the pattern recognition of bioacoustics signal. Each of these definitions of entropies characterizes different aspects of the signal. The entropies are combined with other standard pattern recognition tools such as the Fourier spectral analysis to form a hybrid spectral-entropic classification scheme. The efficiency of the system is tested using a database of sound syllables are obtained from a number of species of Microhylidae frogs. Nonparametric *k*-NN classifier is used to recognize the frog species based on the spectral-entropic features. The result showed that the *k*-NN classifier based on the selected features is able to identify the species of the frogs with relativity good accuracy compared to features relying on spectral contents alone. The robustness of the developed system is also tested for different noise levels.

Keywords: Pattern recognition, k-NN classifier; entropy, spectral centroid.

INTRODUCTION

Pattern recognition is defined as a fundamental solution to variety of problems in real world applications [1]. Pattern recognition is mainly use for categorize an unknown pattern into a specific class based on a suitable similarity measure, in order to assigned the similar patterns into the same classes while dissimilar pattern are classified into different classes.

Extracted features used in sound recognition application are usually selected to characterize and represent the 'finger print' on particular sound. Choosing suitable features is an important part for sound recognition system.

Frog sound is observed as an organized sequence of brief sounds from species-specific vocabulary [2] and brief sounds also defined as syllables [3]. In the pre-

CP1250, *Progress of Physics Research in Malaysia – PERFIK2009,* edited by A. K. Yahya

processing state, a set of useful features are extracted from syllables for pattern recognition usage.

We consider Fourier spectral centroid, Shannon entropy, Rényi entropy and Tsallis entropy as the bioacoustics features determined from a collection of sound syllables of nine frog species. Then, these features are used with *k*-nearest neighbour (*k*-NN) classifier for frog species classification.

EXPERIMENTAL

In this work, a database that consists of nine Microhylidae frogs found in Australia as listed in Table 1 (obtained from http://www.Frogsaustralia.net.au/frogs) were used in the experiments.

Four features were extracted from the sound syllables, namely the spectral centroid, Shannon entropy, Rényi entropy and Tsallis entropy. After all of the syllables from each species were extracted from features, the mean values of features were prepared as the training data in *k*-NN classifiers. The *k*-NN classifiers were then classified the syllables and determined their classes based on the given training data.

In order to examine the performance of the *k*-NN classifier with three entropies that we proposed, two type of classification, consisted of spectral based classifier alone and the hybrid of spectral-entropy based classifier were compared.

Finally, in order to evaluate the sensitivities of the hybrid spectral-entropy based classifier in different of noise levels, the hybrid spectral-entropy classifier was trained with all nine species of Microhylidae frog by adding Gaussian white noise into all of the syllables from the database. Frog species classifications under the noise levels at signal to noise ratio (SNR) of -40dB to -10dB were compared.

TABLE 1. Frog species for Microhylidae

Family	Scientific name	Common name	No. Syllables
Microhylidae	*Cophixalus bombiens*	Buzzing Nurseryfrog	6
	Cophixalus concinnus	Tapping Nurseryfrog; Elegant Frog; Beautiful Nursery-frog	6
	Cophixalus exiguus	Dainty Nurseryfrog; Scanty Frog	6
	Cophixalus hosmeri	Rattling Nurseryfrog; Hosmer's Frog	6
	Cophixalus infacetus	Creaking Nurseryfrog; Inelegant Frog	6
	Cophixalus monticola	Mountain Nurseryfrog	6
	Cophixalus neglectus	Bellenden Ker Nurseryfrog; Neglected Frog	6
	Cophixalus ornatus	Ornate Nurseryfrog; Ornate Frog	6
	Cophixalus saxatilis	Black Mountain Boulderfrog; Rock Frog	6
		Total	54

RESULTS AND DISCUSSION

Referring to Figure 1, our results show that the classifier based on spectral centroid without the entropy has successfully identified all of the frog species except *Cophixalus infacetus* and *Cophixalus neglectus*. This is with general assumption that accuracy of 80% as the cutting point. Where over 80% is considered successfully identified, wise is considered fail.

By introducing the various definition of entropy into the classifier, the classifier based on hybrid spectral-entropy method has successfully identified all nine Microhylidae frog species (refer Figure 1). The entropy based classifier managed to identify nine of the Microhylidae frogs with average accuracy more than 96%.

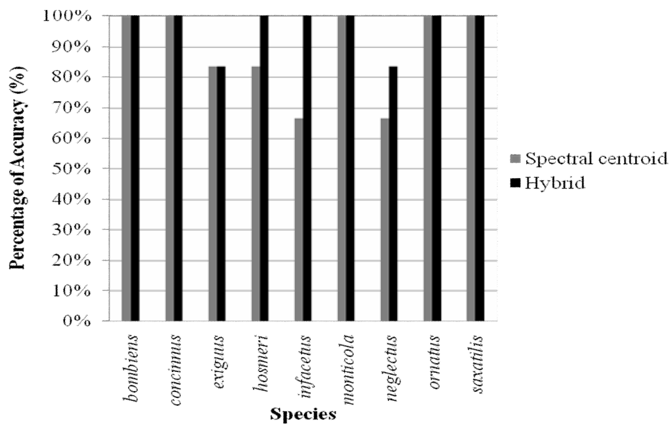

FIGURE 1. Comparison of the performance of spectral and hybrid spectral-entropy based classification of nine Microhylidae frog species

By comparing these two classifiers, between spectral centroid alone and spectral-entropy based, we have seen some significant improvements in the accuracy of classification for entropy based classifier (see Figure 1).

Since, the accuracy of classification based on this hybrid spectral-entropy method showed more than 80% for all nine Microhylidae frog species, it can be concluded that all species were successfully identified.

From Figure 2, we have shown that the identification accuracy of hybrid spectral-entropy method generally was not significantly affected under low noise conditions. The classifier completely misclassified for *Cophixalus exiguus* when the syllables were contaminated with high noise levels (-10dB).

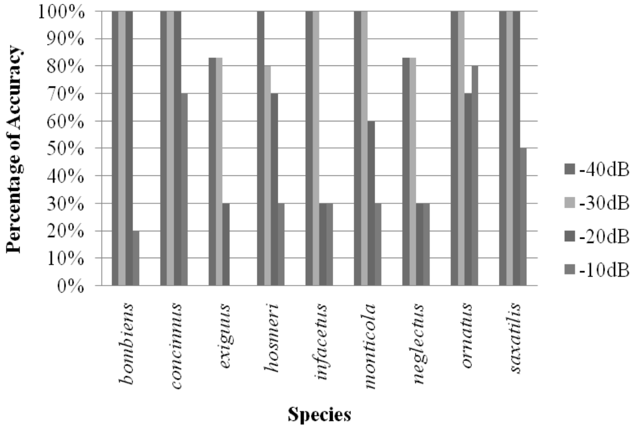

FIGURE 2. Sensitivity of the hybrid spectral-entropy based classifier for different levels of noise contamination.

CONCLUSIONS

In conclusion, we have proposed a new hybrid method for automated frog sound identification based on the concept of entropy. Various definitions of entropies such as the Shannon entropy, Kolmogorov-Rényi entropy and Tsallis entropy have introduced in order to measure the information contents or complexity of the bioacoustics signals. This study has shown the performance of the k-NN classifier can be improved by using entropy approach. By introducing different definition of entropy, we have shown the advantage of spectral-entropy based k-NN classifier that incorporates both the spectral harmonics as well as signal complexity measure for species classification.

ACKNOWLEDGEMENTS

This study was supported by the Fundamental Research Grants No. FRGS0031-ST-1/2006. S.V. Muniandy thanks the Malaysian Ministry of Science, Technology and Innovation (MOSTI) for financial support under e-Sciencefund 16-02-03-6008.

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