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MFCC Feature Classification from Culex and Aedes Aegypti Mosquitoes Noise Using Support Vector Machine

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***Abstract*—Mosquitoes are main vectors for dangerous diseases, such as dengue fever, yellow fever and cikungunya medium from aedes aegypti while filariasis medium from culex [1]. This paper focuses on female mosquitoes of both types because female mosquitoes always bite human or animal to collect blood to obtain protein for egg reproduction [2][3]. The noises of both mosquitoes were recorded and then processed to gain features using MFCC and classified by support vector machine (SVM). Results show that the classification accuracy is about 75.55 %.**

Keywords—culex, aedes aegypti, MFCC, SVM

I. Introduction

Noise of various kinds of mosquitoes such as culex and aedes aegypti appears almost the same to the human ear. But their shapes are not the same, as shown in Fig. 1.

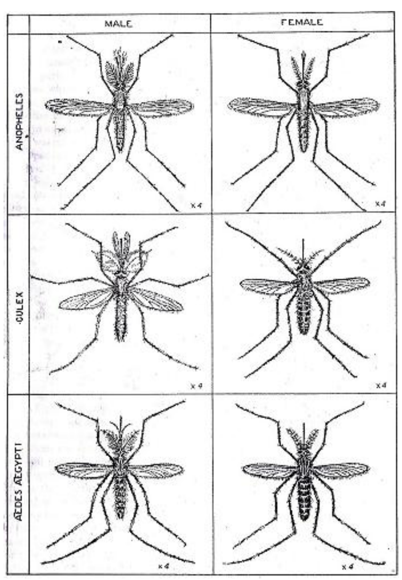

Figure 1. Mosquito's type [4]

According to Fig. 1, the possibility of sound differences among these three types of mosquitoes can be found, although very small. Previous research in the field of biology found that the basic frequency of female aedes aegypti mosquitoes 400 hertz and male 600 hertz [5]. As for other research [6], harmonic average frequency tethered culex male 542.4 $\pm$ 81.60 hertz and female 428.3 $\pm$ 42.92 hertz (mean + standard deviation). Based on previous research [5]–[6] on both mosquitoes culex and aedes aegypti, females can be developed for noise feature classification. In our neighborhood, when close and distant neighbors or close relatives of us have dengue fever, yellow fever, or filariasis, the local government will do the precautions by fogging or giving drugs to kill mosquito larvae or localization so as not to infect other residents. This precaution is sometimes always late because prevention is done in the event of a disaster. Therefore, this research was conducted to create prototype software that can classify two types of mosquitoes that will be expected to be developed to detect the presence of early mosquitoes that cause the disease at least indoors and one day can be installed in a smart-phone with a microphone. Equipment with chemical smells can be used to attract the attention of mosquitoes, and such experiments are related to biological science, chemistry and medicine.

The mosquito that will be the target of research in this paper is culex and aedes aegypti female that taken from a biology laboratory, Faculty of Biology, Gadjah Mada University, Indonesia. The noise is recorded, processed using MFCC to get the noise features [7]–[8] for all of mosquitoes, and then classified by SVM. The main reason we are using SVM for classification method is because it is one of the methods used to detect Parkinson's disease and essential tremor subject based on temporal fluctuation [9] to achieve 100% accuracy, sensitivity and specificity for classification.

This paper is structured as follows. Section II describes the proposed method. Section III shows the experimental results. Section IV gives the conclusion and future work.

II. Methodology

Data collection records of both types of mosquitoes were conducted by separating males and females from each species using rabbit and sugar water included in the mosquito coop. Mosquitoes that bite the rabbit are identified

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as females and those that settle in sugar water are identified as males. Then the female attached to the body of the rabbit is taken by using aspirator tool and put it into a 50 ml empty bottle equipped with an Aiwa WR – 601 microphone. The bottle is closed in order to keep the mosquitoes from going out. We used visual basic programming language to implement MFCC method and R programming language with CRAN Package e1071 library to implement the SVM classification. Recording is taken for every two seconds for each mosquito using the coolEditpro software.

A. *Feature Extraction*

The feature extraction processing of mosquito noise can be seen in the following MFCC diagram in Fig. 2.

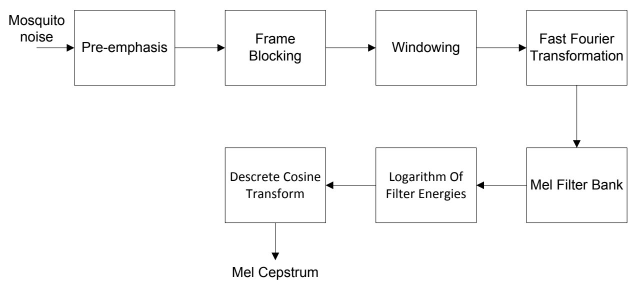

Figure 2. MFCC diagram

The process to obtain MFCC feature is shown in Fig. 2. First we read the mosquito noise as a signal, and then we go to pre-emphasis step until we get mel cepstrum. Those steps will be explained as follows.

1. Pre-emphasis: this process is to use of the filters to remove the sound reflection echoes that occur during the recording process is complete, because it uses a bottle medium.

$$y[n] = x[n] - \alpha\, x[n-1] \quad (1)$$

where $y[n]$ is pre-emphasis signal and, α is parameter pre-emphasis that taken as 0.95.

2. Frame Blocking: the result of this pre-emphasis process is then cut into small pieces, where each part is called a frame to facilitate signal analysis. The amount of data in one frame (N) contains 512 points, while the distance between frames (M) is 200 points. Thus, the number of frames (L) for the data is 4000 points (this value is taken half of the sampling frequency).

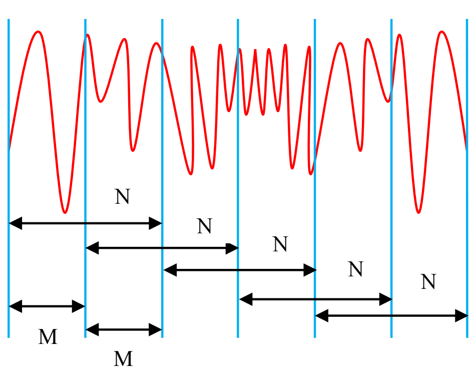

Figure 3. Frame blocking

3. Windowing: the recording shows the sound of mosquitoes up and down depending on whether they are moving toward or away from the microphone. As a result, it looks nonlinear so we apply a hamming window filter.

$$w(i) = 0.54 - 0.46(1 - \cos(2\pi \frac{1}{n})), \text{ for } i = 0, \ldots (n-1) \quad (2)$$

where N is number of samples and $w(i)$ is signal from windowing result.

4. Fast Fourier Transform: the next step is to change each frame from time domain to frequency domain. FFT is an algorithm that implements Discrete Fourier Transform (DFT).

$$RealX(k) = \sum_{n=0}^{N-1} x(i) * \cos(\frac{2\pi k i}{N}) \quad (3)$$

$$ImaginerX(k) = -\sum_{n=0}^{N-1} x(i) * \sin(\frac{2\pi k i}{N}) \quad (4)$$

where N is number of samples, $k = 0,1,2, ..., N/2$ and $X(k)$ is the signal until i^{th} point.

The next process is to calculate the magnitude of the FFT [10].

$$X_{mag}(k) = |X(k)| = \sqrt{(RealX(k))^2 + (ImaginerX(k))^2} \quad (5)$$

where k also corresponds to the frequency $f(k) = (k.f_s)/N$, f_s is the sampling frequency in Hertz and $w(n)$ is time-window. Spectrum of magnitude $X|(k)|$ scales on frequency and magnitude.

5. Mel filter bank, is a collection of triangular filters defined by center frequency fc(m), formulated as

$$H(k,m) = \begin{cases} 0 & \text{for } f(k) < f_c(m-1) \\ \dfrac{f(k) - f_c(m-1)}{f_c(m) - f_c(m-1)} & \text{for } f_c(m-1) \le f(k) \le f_c(m) \\ \dfrac{f(k) - f_c(m+1)}{f_c(m) - f_c(m+1)} & \text{for } f_c(m) \le f(k) \le f_c(m+1) \\ 0 & \text{for } f(k) \ge f_c(m+1) \end{cases} \quad (6)$$

The frequency of the filter bank is calculated approach of mel scale, which is

$$\phi = 2595 \log_{10}(\frac{f}{700} + 1) \quad (7)$$

Then the resolution frequency is fixed in the calculation of the Mel Scale, according to the logarithmic scale of the frequency loop, using the formula

$$\Delta\phi = \frac{\phi_{\max} - \phi_{\min}}{M+1} \quad (8)$$

where ϕ_{max} is the highest frequency of bank filters on a mel scale, calculated from f_{max} by using Eq. (7), ϕ_{min} is the lowest frequency in mel scale medium with relation to f_{min} and M is number of filter bank. The center frequency on a mel scale given by

$$\phi_c(m) = m \cdot \Delta\phi \quad (9)$$

where, m = 1, 2, …, M. To change the frequency of a bank filter center into a learning frequency, we use the inverse of Eq. (7).

$$f_c(m) = 700(10^{\frac{\phi_c(m)}{2595}} - 1) \quad (10)$$

Then Eq. (10) is substituted into Eq. (6) to obtain the Mel filter from the Bank.

6. Logarithm Of Filter Energies: The next step is to get the logarithmic scale frequency using the Mel-filter bank H(k, m) by the formula

$$X'(m) = \log\left(\sum_{k=0}^{N-1} |X(k)| \cdot H(k,m)\right) \quad (11)$$

For m = 1, 2, …, M, where M is number of filter bank and $M < N$.

Discrete Cosine Transform: the last process is the MFCC obtained by computing DCT $X'(m)$ using the equation.

$$c(l) = \sum X'(m) \cos(l \frac{\pi}{M}(m - 0.5)) \quad (12)$$

For l = 1,2,…, M. where $c(l)$ is MFCC until l^{th}.

Then only 13 cepstral coefficients of each vector of the mosquito vectors will be used as the characteristic of the mel frequency which is the input for the SVM to be classified.

B. Classification

Classification using SVM works in a linear fashion, and then methods have been developed for non-linear problems. We use some kernel functions to find the hyper-plane between vectors. The most commonly used kernel function [11] is

- Linier : $K(x_i, x_j) = x_i^T x_j$
- Polynomial : $K(x_i, x_j) = (\gamma.x_i^T x_j + r)^d$, $\gamma > 0$
- RBF : $K(x_i, x_j) = \exp(-\gamma|x_i - x_j|^2)$, $\gamma > 0$
- Sigmoid : $K(x_i, x_j) = \tanh(\gamma.x_i^T x_j + r)$

The regression function is expressed mathematically [12]:

$$f(x) = w \cdot \phi(x) + b \quad (13)$$

where $\phi(x)$ is higher dimensional mapping training data. After processing Lagrange multipliers, we can apply the formula:

$$\max_{\alpha_{i \geq 0}} \left[\sum_i \alpha_i - \frac{1}{2}\sum_{i,j} \alpha_i \alpha_j y_i y_j K(x_i, x_j)\right] \quad (14)$$

where $K(x_i, x_j)$ denotes a kernel function.

III. Result

This research used 150 mosquitoes noise samples for each type so that all were amounted to 300 samples, and the mosquitoes used were two types of aedes aegypti females and culex females. Then the data were divided so that there are 80% training data while 20% for testing data. The experiment was conducted to know the accuracy of classification with variation of gamma and C parameters in SVM by using the Radial Basis Function (RBF) function on bank filter variations 10, 11, 12 and 13. For gamma and C parameters in SVM, the range is between 0.1 and 1. The experimental results are shown in Table I.

TABLE I. THE CLASSIFICATION SUMMARY USES THE GAUSSIAN RBF KERNEL FUNCTION USING THE PARAMETER GAMMA = 0.9 AND C = 1 WITH THE VARIATION OF THE NUMBER OF FILTER BANKS

Number of Filter	Accuracy Rate (%)
10	68.89
11	75.55
12	67.50
13	68.66

The difference between these two types of mosquitoes is very small and that it is almost impossible to distinguish one another from the flying position and able to move quickly and easily in the bottle when the noise was recorded. In general mosquitoes placed in the bottle will fly with agility due to the condition of new and narrow space. However, some of these mosquitoes experience stress and die immediately after going through the recording process, especially on aedes aegypti mosquitoes. The experiments are done with a couple of times for every mosquito in order to get the best sound during recording process. The test results shown in Table I are the most optimal test results for the classification of types of mosquito noise with the gamma parameter = 0.9 and C = 1, showing that the accuracy of data is 75.55% and the number of filters is 11.

In comparison, we also presented the classification results using the back-propagation [13]. Using 3 layers, one input layer X_{11}, X_{12}, ... X_{mn} plus 1 node bias I where n, the number of cepstral coefficients, is 13 for each vector mosquitoes noise and m is the number of mosquitoes noise data, one hidden Layer Z_1, Z_2, Z_3, ... Z_8 plus 1 bias node I and two output layers are Y_1 and Y_2.

Back-propagation test results were done by finding the most optimal learning rate parameters to determine the best number of filters for the type of mosquito noise signal classification, and a summary of the test results are shown in Table II.

TABLE II. SUMMARY OF TEST RESULTS WITH ERROR 0.001 AT THE LEARNING RATE 0.01

Number of filter	Epoch	Accuracy Rate (%)
10	452252	66.51
11	457661	72.56
12	462571	72.37
13	463367	69.13

Table II shows that the highest accuracy test results occur with the number of filters being 11 for 72.56%. From the results of comparison between SVM by using RBF kernel with back-propagation, it shows that SVM is better with the result of accuracy 75.55%, compared with back-propagation which only yields accuracy 72.56%. It also shows that the effect of the number of filters will affect its accuracy.

IV. Conclusion and Future Work

Many methods have been proposed to classify the types of sound, but so far no one has classified the type of mosquitoes. In addition, it is almost difficult to get mosquitoes to be sampled and it also needs patience in doing this research especially during the recording process. We offer a method to classify mosquitoes using SVM with the feature of MFCC. From the test results they show that the results obtained SVM using RBF kernel is better than previous research using back-propagation. This research may also be improved by classification using deep neural network, as well as other data retrieval methods to get higher accuracy.

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