Wave File Features Extraction using Reduced LBP

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ABSTRACT

In this work, we present a novel approach for extracting features of a digital wave file. This approach will be presented, implemented and tested. A signature or a key to any wave file will be created. This signature will be reduced to minimize the efforts of digital signal processing applications. Hence, the features array can be used as key to recover a wave file from a database consisting of several wave files using reduced local binary patterns (RLBP). Experimental results are presented and show that the proposed RLBP method is at least 3 times faster than CSLBP method, which mean that the proposed method is more efficient.

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1. INTRODUCTION

The Digital wave file (DWF) represents the sampled and quantized sound wave which happens to be above or below the equilibrium or ambient air pressure [1], [2]. The sampled values are organized in one column (for mono DWF) or in two columns (for stereo DWF), so we can deal with DWF as a matrix which consists of positive and negative values over the entire range of samples [3], [4], [5]. Figure 1 shows some samples of a DWF, while the Figure 2 shows the wave of a DWF.

\[
\begin{array}{cccc}
-0.0156 & -0.0156 \\
-0.0156 & -0.0156 \\
-0.0156 & -0.0156 \\
-0.0076 & -0.0076 \\
-0.0076 & -0.0076 \\
0 & 0 \\
-0.0076 & -0.0076 \\
-0.0076 & -0.0076 \\
-0.0076 & -0.0076 \\
\end{array}
\]

Figure 1. Samples of DWF
One of the most used applications involved with DWF processing is voice recognition. Hence, most of these applications use the nature of DWF to extract voice feature by mean of calculating several parameters like zero-crossing, dynamic range and peak value [6], [7], [15]. Calculating these parameters require understanding the voice nature, and some time they do not give an acceptable recognition ratio if we use them to recognize the voice [6], [7], [8].

To avoid the above mentioned weakness, we propose a method which can deal with DWF using two dimensional matrix. This can be done by converting the one or two column voice array to two dimensional matrix with multiple rows and columns. Hence, the DWF can be represented as a gray image, as shown in Figure 3.

In this paper, once the DWF is converted to a matrix, then the features of DWF can be obtained using the neighborhood concepts, by considering the point in the center and the point neighbors as shown in Figure 4. This technique is called local binary pattern (LBP) [9]. LBP computes binary numbers by labeling the pixels of an image through thresholding the 3x3-neighborhood of each pixel with the center value. The procedures of calculating these patterns are shown in Figures 5 and Figure 6 [10], [11],[14]. Figure 7 shows an example of calculating LBP for a matrix.
Figure 4. Point neighborhood

Figure 5. Generating binary pattern

Figure 6. LBP calculation procedures
Using the LBP method to create features for signal recognition leads to extra efforts because the size of the generated features array is very big and it contains 256 entries (repetitions for the values from 0 to 255) [10]. To minimize the number of entries in the features array we can use center symmetric LBP (CSLBP) which can generate a features array with 16 entries [11], [12],[13]. The procedure of calculating CSLBP is shown in Figure 8, while the Figure 9 shows an example of calculating CSLBP. It can be shown from Figure 9 that the CSLBP reduces the feature array entries to 16. Hence, the CSLBP minimize the requirements needed to apply voice recognition process.

![Original Matrix](image)

**Original_matrix =**

|   |   |   |   |   |
|---|---|---|---|---|
| 15 | 20 | 30 | 40 | 15 |
| 20 | 100| 105| 30 | 40 |
| 50 | 30 | 105| 50 | 50 |
| 100| 10 | 100| 150| 100|
| 15 | 20 | 20 | 20 | 20 |

**LBP_matrix =**

|   |   |   |   |   |
|---|---|---|---|---|
| 0  | 0  | 0  | 0  |
| 0  | 24 | 32 | 251|
| 0  | 222| 18 | 249|
| 0  | 255| 10 | 0  |

Figure 7. LBP calculation example

![Figure 7](image)

![Figure 8](image)

**Figure 8. Procedures to calculate CSLBP**

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2. PROPOSED METHOD

The proposed method is based on CSLBP to create a DWF features array. The main contribution of the proposed method lay in reducing the number of entries from 16 to 4 entries. The obtained DWF features array by proposed method can be used for various applications such as:

a. Identifying the voice, because the feature array is a unique array for each DWF.

b. Using features array as a key to retrieve a wave file from a database consisting of several wave files.

c. Using features array as an input data set to any recognition or expert system.

d. Finding whether the DWF is disrupted or not, knowing the accurate features array of original DWF.

The proposed method using reduced LBP can be implemented by applying the following steps:

a. Get DWF.

b. Get the size of the DWF array (r: row, c: columns which is always 1 for mono files or 2 for stereo one).

c. Reshape the matrix of DWF to one column array(R).

d. Get M as a multiplication of r and c.

e. Find S as a floor of the square root of M.

f. Square S to get SS.

g. Get a number of values of R equal to SS and store them in RR array.

h. Reshape RR array to a square matrix (MR) (with rows=S, and columns=S).

i. Initialize features array to zero (FA=zeros (4, 1)).

j. For each point in MR calculate the reduced LBP applying the following steps as shown in Figure 10:

1) Find a threshold value using the following formula:

\[ T = \frac{(I(i,j+1) + I(i+1,j)+I(i,j-1)+I(i-1,j)+I(i+1,j+1)+I(i+1,j-1)+I(i-1,j-1)+I(i-1,j+1)-8*I(i,j))}{9}; \]

2) Find the following two binary digits

\[ A0 = (I(i,j+1) + I(i+1,j)+I(i,j-1)-I(i-1,j) > T) \]
\[ B0 = ((I(i+1,j+1)+I(i+1,j-1)-I(i-1,j-1)-I(i-1,j+1) > T) \]

3) Get the index of FA as:

\[ IFA = A0*2^0+B0*2^1 \]

4) Increment FA(IFA=1) by 1

k. Save FA.

The following Matlab code was written to implement the proposed method:

```matlab
[aa fs]=wavread('C:\Users\win 7\Desktop\voice\horse.wav');
```

Figure 9. CSLBP calculation example
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$n1 \times n2 = \text{size}(aa); a1 = \text{reshape}(aa, n1 \times n2, 1); b = n1 \times n2;
b1 = \text{floor}(\sqrt{b}); a2(:, 1) = a1(1:b1 \times b1, 1);
I = \text{reshape}(a2, b1, b1);
size(I)

$h = \text{zeros}(4, 1);
[y x] = \text{size}(I);
for i = 2:y-1
    for j = 2:x-1
        $T = \frac{(I(i, j+1) + I(i+1, j) + I(i-1, j-1) + I(i+1, j+1) + I(i+1, j-1) + I(i-1, j-1) + I(i-1, j+1) - 8 \times I(i, j))}{9};$
        
        % keeping $I(j, i)$ as center we compute CSLBP
        $a = (I(i, j+1) + I(i+1, j) - I(i, j-1) - I(i-1, j) > T) \times 2^0 ;$
        $b = (I(i+1, j+1) + I(i+1, j-1) - I(i-1, j-1) - I(i-1, j+1) > T) \times 2^1 ;$
        $e = a + b;$
        $h(e+1) = h(e+1) + 1;$
    end
end
$h$

One of the sample DWF used in the implementation process size=15547 * 2

then

fix (sqrt (15547 * 2))=176

Voice matrix size=176*176

3. RESULTS AND ANALYSIS

In this section, The proposed method was implemented several times using various DWF with different sizes, Table 1 shows some implementation samples:

| Wave file   | Size(byte) | Features       |
|-------------|------------|----------------|
| 1(bird.wav) | 1254528    | 44770          |
| 2(cow.wav)  | 495424     | 18148          |
| 3(cow2.wav) | 279904     | 11499          |
| 4(dog.wav)  | 737104     | 28220          |
| 5(dolphin.wav) | 628704     | 23706          |
| 6(donkey.wav) | 1903904    | 73216          |
| 7(duck.wav) | 3288576    | 122618         |
| 8(elephant.wav) | 360272     | 14082          |
| 9(horse.wav) | 248752     | 8910           |

The feature array is very sensitive to any changes in the DWF, even if we change one value in the file as shown in Table 2, so this feature array can be used as an identifier or a primary key to retrieve the wave file.

| Wave file   | Changes       | Features       |
|-------------|---------------|----------------|
| 1           | No change     | 44770          |
| 2           | Wav(220)=0.0038 changed to 0.5 | 44772 |
| 3           | Wav(220)=0.00095 changed to 0.5 | 18148 |
| 4           | Wav(220)=0.00078 changed to 0.5 | 11499 |
| 5           | Wav(220)=0.00019 changed to 0.5 | 28220 |
| 6           | Wav(220)=0.0056 changed to 0.5 | 11496 |
| 7           | Wav(220)=0.0075 changed to 0.5 | 28221 |
| 8           | Wav(220)=0.0210 changed to 0.5 | 23706 |
| 9           | Wav(220)=0.0156 changed to 0.5 | 23708 |

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From the results of implementation, we can raise the following facts:

a. Each DWF has a unique features array.

b. FA consists of only 4 elements.

c. FA does not depend on DWF size and has always the size of 32 bytes.

d. FA can be used as a key or a signature to deal with digital wave files.

e. Using 4 element array reduces all the efforts concerning any application that deals with digital wave files.

The proposed RLBP method was implemented several times using various wave files with different sizes, the time to extract features was computed (T2), the same files were treated using CSLBP method and the features extraction time was also computed (T1). The experimental results are shown in Table 3. From Table 3, it can be seen that the speedup of the proposed method is at least 3 times faster, which mean that the proposed method is more efficient compared with CSLBP method.

| Wave file size(byte) | CSLBP features extraction time (Sec.) T1 | Proposed RLBP features extraction time (Sec.) T2 | Speedup |
|----------------------|---------------------------------|---------------------------------|--------|
| 2880000              | 1.953460                        | 0.589395                        | 3.3143 |
| 1903904              | 0.939946                        | 0.290760                        | 3.2327 |
| 1254528              | 0.418782                        | 0.120215                        | 3.4836 |
| 737104               | 0.338388                        | 0.098481                        | 3.4361 |
| 628704               | 0.100056                        | 0.044843                        | 2.2313 |
| 495424               | 0.030078                        | 0.009357                        | 3.2145 |
| 360272               | 0.030955                        | 0.008587                        | 3.6049 |
| 3288576              | 0.030710                        | 0.008232                        | 3.7306 |
| 279904               | 0.030672                        | 0.007565                        | 4.0545 |
| 248752               | 0.028529                        | 0.006089                        | 4.6853 |

4. CONCLUSION

A new method of digital wave file feature extraction was proposed, implemented and tested. The proposed method has some advantages comparing with other existing method and it can suit any application dealing with wave files. The extracted features were unique to a wave file and they can be used as an excellent key or signature for a digital wave file.

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