Dynamic Window Search and Probability Dominated Algorithm for Fast Vector Quantization Encoding

Yung-Gi, Wu (IEEE member)
Department of Computer Science and Information Engineering
Institute of Applied Information
Leader University, Tainan, Taiwan

Vector quantization (VQ), which has been widely applied in speech and image coding, provides an efficient technique for signal compression due to its excellent rate-distortion performance. However, it requires expensive encoding time to find the closest codeword to the input vector. This paper proposes a fast encoding method to speed up the closest codeword algorithm by accounting the occurrence of each codeword in the codebook for every input vector before practical encoding. Then, based on the occurrences, the search order and search window size are determined.

The whole VQ system is constituted by two major tables; one is the codebook and the other is the table recording the information of search order and search range which is called SOSR table here. For any input vector \( x \), it is unnecessary to search the whole codebook to find the best match codeword. We just search part of the whole codebook according to the SOSR table. In the pre-processing procedure, we use full search algorithm to find all the best match codewords’ indices during the generation of SOSR table for every input vector \( x \). In the meanwhile, we also calculate the occurrence of the entire searched best match indexes. However, the input vector \( x \) is 16 dimension; the memory used to store SOSR will not be tolerant. Therefore, we use the mean value of input vector \( x \) to be the key to find its corresponding SOSR information. The data structure of SOSR is given as follows:

```c
struct SOSR_type {
    int search_window_length;
    pointer next_codeword;
};
struct SOSR_type SOSR_table[256];
```

Simulations results demonstrate that the little preprocessing and memory cost significant reduce the search time while maintaining the same encoding quality as that of the full search algorithm. The average number of arithmetic operations per pixel when codebook size is equal to 256 is 18.5447 to encode Lena image. The saved running time compared to full search VQ is more than 98.42%. It is found from the literatures that the proposed algorithm outperforms all existing VQ encoding algorithms.

<table>
<thead>
<tr>
<th>methods</th>
<th>Average total arithmetic operation per pixel</th>
<th>CPU running time (compared to full search)</th>
<th>PSNR (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full search</td>
<td>768</td>
<td>100%</td>
<td>30.112</td>
</tr>
<tr>
<td>PDS</td>
<td>133.2</td>
<td>20.24%</td>
<td>30.112</td>
</tr>
<tr>
<td>TIE</td>
<td>49.85</td>
<td>6.40%</td>
<td>30.112</td>
</tr>
<tr>
<td>Proposed method +PDS (w)</td>
<td>18.5447</td>
<td>1.58%</td>
<td>30.112</td>
</tr>
</tbody>
</table>