Alternative Methods for Codebook Design in Vector Quantization

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Introduction: A vector quantizer maps a multidimensional vector space into a finite subset of reproduction vectors called a codebook. For codebook optimization the well known LBG algorithm or a Simulated Annealing technique are commonly used. Two alternative methods the fuzzy-c mean (FCM) and a genetic algorithm (GA) are proposed here.

Alternative methods: As distinct from [1] the FCM has been realized with the average distortion as the objective function. The initial membership matrix was computed from the initial codebook. The parameter $m = 1.25$ has turned out to be the most suitable.

GA explores the given search space parallel by means of iterative modifications of a population of potential solutions (chromosomes). Here the chromosomes are described as strings of indices numbering the representing code vectors. A reproduction process which consists of three main operations: selection, crossover and mutation improves these chromosomes by transmitting properties of the fitter chromosomes to the next generation [2]. Therefore chromosomes must be evaluated by a fitness value depending on the average distortion in our case, and so a conjunction with the LBG algorithm is inherent in this method. The right reproduction way and parameter settings can only be found empirically where importance was attached to a fast convergence of the algorithm.

Simulation and conclusion: In order to illustrate the algorithm performance a DCT-VQ has been chosen. The fixed partition scheme based on the mean energy per coefficient is shown in figure 1 for test image "Lena". Apart from the DC coefficient scalar encoded by 8 bit each of the seven block groups are quantized separately with 256 code vectors. The initial code words are found by the Binary Splitting method. In contrast to the LBG algorithm both methods improve codebook quality remarkably as shown in table 1 for the first group of lower frequencies. The FCM needs much more time to converge than the GA. The SNR for test image "Lena" has been increased by 1.45 dB (FCM) or 1.95 dB (GA).

<table>
<thead>
<tr>
<th>method</th>
<th>MSE</th>
<th>IN</th>
<th>TR</th>
</tr>
</thead>
<tbody>
<tr>
<td>LBG</td>
<td>185.8</td>
<td>-</td>
<td>1.0</td>
</tr>
<tr>
<td>FCM</td>
<td>138.0</td>
<td>17</td>
<td>1142.2</td>
</tr>
<tr>
<td>GA*</td>
<td>119.9</td>
<td>23</td>
<td>20.6</td>
</tr>
</tbody>
</table>

Table 1: Algorithm performance for the first group
IN: iteration number for FCM-MSE, *: IN = 1000
TR = $T_{meth}/T_{LNG}$ for IN = 1 (Intel DX 486)

References: