# ECG Signal Compression using Morphological Haar Wavelet Transform

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**Abstract.**This paper analyzes the performance of Morphological Haar (Mhaar) Wavelet Transform for quality controlled electrocardiogram (ECG) compression. This transform is compared with the Haar transform. And results show that Mhaar wavelet transform gives better compression ratio (CR) at high percentage of root mean square difference (PRD).

**Keywords.**ECG Signal, Quality controlled compression, Morphological Haar Wavelet Transform.

## 1. Introduction

The Morphological Haar (Mhaar) Wavelet is an uncouple wavelet decomposition scheme. The main dissimilarity with the classical haar wavelet is that the linear signal analysis filter of the latter is replaced by an erosion (or dilation), i.e., by taking the minimum (or maximum) over two samples. The Mhaar wavelet decomposition method can do better work in preserving edges as compare to the linear case. This is expected, since the signal analysis filters in the linear Haar wavelet decomposition method are linear lowpass filters and as such smooth-out edges. The signal analysis filters in the Mhaar case are non-linear, and as such may preserve edge information [1]. In this paper Mhaar wavelet transform is used for quality controlled ECG compression. The performance analysis, the metrics like compression ratio (CR), the percentage of root mean square difference (PRD) are calculated according to [2]-[9].
The pseudo code for the algorithm is explained in [2]-[9].

## 2. Results and Discussions

The effectiveness of the Mhaar wavelet transform is tested by experimentation on the well known ECG database, MIT-BIH Arrhythmia [10]. The results presented in Table 1 represent the performance of Mhaar wavelet transform in terms of CR at fixed PRD=1, PRD=2 and PRD=3 respectively on different ECG signal records. From the numerical results, it is observed that PRD before quantization (BPRD) is nearly equal to PRD after quantization (QPRD).

Table 2 compares the proposed method to that compression methods reported in the literature. For comparison the average CR and the average PRD of the proposed method are taken according to that reported in the literature. Testing dataset is of 2 minute duration long (43200 samples) lead extracted from records 100, 101, 102, 103, 107, 109, 111, 115, 117, 118 and 119. This dataset has been chosen for Table 2 because it has been used in the [2]. Table 2 concludes that the proposed method gives better CR to that reported in [11]-[13] and at high PRD (4.7280) as compared to Haar transform.

## 3. Conclusion

The results show that the compression ratio of Mhaar wavelet Transform gives high compression ratio at high PRD (4.7280) as compared to Haar transform. The effort presented in this paper may be useful for the design of efficient ECG compression scheme.

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**Table 1.**Performance of ECG compression with Mhaar Wavelet Transform on different ECG signals.

**Mhaar Wavelet Transform, [1]Qbits=12, Samples=43200, Time=2 min**

| Signal | [2]UPRD=1 | | | [2]UPRD=2 | | | [2]UPRD=3 | | |
|---|---|---|---|---|---|---|---|---|---|
| | [3]BPRD | [4]QPRD | [5]CR | [3]BPRD | [4]QPRD | [5]CR | [3]BPRD | [4]QPRD | [5]CR |
| 121 | 1.0195 | 1.0166 | 12.9243 | 1.9005 | 1.8976 | 22.2222 | 3.0249 | 3.0230 | 44.7289 |
| 122 | 0.9510 | 0.7829 | 10.8434 | 1.8933 | 1.8933 | 13.7755 | 2.9704 | 2.9704 | 21.0638 |
| 205 | 0.9856 | 1.1373 | 11.1780 | 1.9929 | 1.9929 | 12.4320 | 3.0005 | 3.0005 | 15.7476 |
| 103 | 1.0012 | 1.0994 | 10.9695 | 2.0076 | 2.1278 | 11.0987 | 2.9681 | 3.0842 | 12.9187 |
| 104 | 1.0074 | 1.2343 | 11.6654 | 1.9893 | 1.9893 | 11.3641 | 3.0555 | 2.3905 | 11.5116 |
| 221 | 0.9228 | 1.2414 | 11.3035 | 1.9803 | 1.9803 | 11.0041 | 2.5257 | 2.4491 | 10.9191 |
| 201 | 0.4705 | 0.4705 | 14.9924 | 1.8888 | 1.8888 | 11.5183 | 3.0231 | 3.0231 | 12.1448 |
| 203 | 1.0049 | 1.0127 | 11.3316 | 1.9397 | 1.9257 | 10.8216 | 3.0040 | 3.0133 | 11.5049 |
| 233 | 0.9958 | 1.1194 | 10.6873 | 2.0140 | 2.0212 | 10.9011 | 2.9047 | 2.7500 | 11.3424 |
| 109 | 0.7401 | 0.7401 | 11.7974 | 1.9955 | 1.9955 | 11.7554 | 2.9472 | 2.9472 | 13.9863 |
| 112 | 0.9306 | 0.9306 | 12.3185 | 1.9869 | 1.9869 | 19.9650 | 3.0229 | 3.0229 | 29.6259 |
| 217 | 0.9587 | 1.0459 | 11.2649 | 2.0141 | 2.1992 | 12.6171 | 2.9762 | 3.0664 | 14.1563 |

[1]Qbits- bits used for quantization [2]UPRD- user defined PRD
[3]BPRD- PRD before quantization [4]QPRD- PRD after quantization [5]CR-Compression ratio

**Table 2.**Compression results

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Proposed method with Mhaar wavelet Transform** | **PRD** | 2.64 | 2.80 | 3.47 | 3.75 | 4.12 | 4.78 | 5.76 |
| | **CR** | 14.90 | 15.62 | 17.91 | 18.74 | 19.99 | 22.02 | 24.58 |
| **Haar Transform [2]** | **PRD** | 2.64 | 2.87 | 3.46 | 3.72 | 4.15 | 4.78 | 5.74 |
| | **CR** | 17.21 | 17.95 | 19.33 | 19.80 | 20.69 | 21.89 | 23.27 |
| **Average CR [11]** | **PRD** | 2.64 | 2.88 | 3.46 | 3.73 | 4.15 | 4.80 | 5.76 |
| | **CR** | 7.05 | 8.28 | 10.89 | 11.62 | 12.46 | 13.49 | 14.74 |
| **Average CR [12]** | **PRD** | 2.64 | 2.88 | 3.46 | 3.73 | 4.15 | 4.80 | 5.76 |
| | **CR** | 9.07 | 10.02 | 11.54 | 12.11 | 12.85 | 13.86 | 15.06 |
| **Average CR [13]** | **PRD** | 2.66 | 2.89 | 3.48 | 3.77 | 4.18 | 4.81 | 5.79 |
| | **CR** | 10.84 | 11.46 | 13.45 | 14.29 | 15.43 | 17.10 | 19.64 |