Supplementary Material for “Optimal Spread Spectrum Watermark Embedding via a Multistep Feasibility Formulation”

H. Oktay Altun, Student Member, IEEE, Adem Orsdemir, Student Member, IEEE,
Gaurav Sharma, Senior Member, IEEE, and Mark F. Bocko, Member, IEEE.

This document provides supplementary material, specifically results for additional images, for the paper:

Fig. 1. Watermarked versions of the Goldhill image obtained for the four different optimization formulations. (a) Maximizing embedding strength. PSWR of the image is 25.07 dB. (b) Minimizing frequency weighted perceptual distortion. PSWR of the image is 38.84 dB. (c) Maximizing robustness to compression. PSWR of the image is 25.31 dB. (d) Minimizing the watermark texture visibility. PSWR of the image is 38.38 dB.
Fig. 2. Embedded watermark signals corresponding to the difference $X_w - X_0$ between the watermarked Goldhill image and the original Goldhill image for the four different optimization formulations. (a) Maximizing embedding strength. (b) Minimizing frequency weighted perceptual distortion. (c) Maximizing robustness to compression. (d) Minimizing the watermark texture visibility. Values have been scaled by a factor of 4 and translated to a mid gray value of 128 to make differences clearer and to allow representation of both positive and negative values.
Fig. 3. Frequency domain distribution of watermark power for the optimally watermarked Goldhill images. The figures represent the magnitudes of the embedded watermark signals for the four different optimization formulations. (a) Maximizing embedding strength. (b) Minimizing frequency weighted perceptual distortion. (c) Maximizing robustness to compression. (d) Minimizing the watermark texture visibility.
Fig. 4. Watermarked versions of the Tank image obtained for the four different optimization formulations. (a) Maximizing embedding strength. PSWR of the image is 25.48 dB. (b) Minimizing frequency weighted perceptual distortion. PSWR of the image is 37.83 dB. (c) Maximizing robustness to compression. PSWR of the image is 25.57 dB. (d) Minimizing the watermark texture visibility. PSWR of the image is 37.59 dB.
Fig. 5. Embedded watermark signals corresponding to the difference $X_w - X_0$ between the watermarked Tank image and the original Tank image for the four different optimization formulations. (a) Maximizing embedding strength. (b) Minimizing frequency weighted perceptual distortion. (c) Maximizing robustness to compression. (d) Minimizing the watermark texture visibility. Values have been scaled by a factor of 4 and translated to a mid gray value of 128 to make differences clearer and to allow representation of both positive and negative values.
Fig. 6. Frequency domain distribution of watermark power for the optimally watermarked Tank images. The figures represent the magnitudes of the embedded watermark signals for the four different optimization formulations. (a) Maximizing embedding strength. (b) Minimizing frequency weighted perceptual distortion. (c) Maximizing robustness to compression. (d) Minimizing the watermark texture visibility.