A DCT Domain Visible Watermarking Technique for Images

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What is Digital Watermarking?

Digital watermarking is defined as a process of embedding data (watermark) into a multimedia object to help to protect the owner's right to that object. The embedded data (watermark) may be either visible or invisible.
What is Visible Watermarking?

In visible watermarking of images, a secondary image (the watermark) is embedded in a primary (host) image such that watermark is intentionally perceptible to a human observer.
Desired Characteristics of Visible Watermarks:

- A visible watermark should be obvious in both color and monochrome images.
- The watermark should be spread in a large or important area of the image.
- The watermark should be visible yet must not significantly obscure the image details.
- The watermark must be difficult to remove.
Visible Watermarking in DCT Domain

- Let $c_{ij}(n)$ are the DCT coefficients of the host image block and $w_{ij}(n)$ the DCT coefficients of the watermark image block.
- The DCT coefficients of the Watermarked image are then obtained as follows:

$$c'_{ij}(n) = \alpha_n c_{ij}(n) + \beta_n w_{ij}(n) \quad n = 1,2,...$$

- The $\alpha_n$ and $\beta_n$ are scaling and embedding factors for block $n$ respectively.
Previous Works

• In [4] the image is divided into different blocks and blocks are classified by perceptual methods to 6 different groups.
• 6 different values of $\mathcal{O}_n$ and $\mathcal{O}_n$ are used.
• No mathematical model is used.
• The algorithm does not work well when the image has very less number of objects.
Present algorithm

• This does not classify the blocks into different groups.
• Each block is assigned a different $\alpha_n$ and a different $\beta_n$ basing on its texture. Thus the chances of image quality degradation is less.
• The algorithm can easily be automated.
• The algorithm is also works for images with less objects.
Factors considered to maintain Image Quality:

- The edge blocks should be least altered to avoid significant distortion of the image.
- The distortion visibility is low when the background has strong texture.
- The blocks with mid-intensity values ($\mu_n \approx \mu$) are more sensitive to noise than that of low intensity blocks ($\mu_n < \mu$) as well as high intensity blocks ($\mu_n > \mu$).
Finding Scaling and Embedding Factors:

- The $\alpha_n$ and $\beta_n$ for edge blocks are taken to be $\alpha_{\text{max}}$ and $\beta_{\text{min}}$ respectively.
- For non-edge blocks $\alpha_n$ and $\beta_n$ are computed as:
  \[
  \alpha_n = \sigma'_n \exp. \left( - (\mu'_n - \mu')^2 \right) \\
  \beta_n = \left(1/\sigma'_n\right) \left(1 - \exp. \left( - (\mu'_n - \mu')^2 \right)\right)
  \]
  where, $\mu'_n$, $\mu'$ are the normalized values of $\mu_n$ and $\mu$ respectively, and $\sigma'_n$ is normalized logarithm of $\sigma_n$ (the variance of the AC DCT coefficients).  

- $\alpha_n$ and $\beta_n$ are then scaled to the ranges $(\alpha_{\text{min}}, \alpha_{\text{max}})$ and $(\beta_{\text{min}}, \beta_{\text{max}})$ respectively, where $\alpha_{\text{min}}$ and $\alpha_{\text{max}}$ are the minimum and maximum values of the scaling factor, and $\beta_{\text{min}}$ and $\beta_{\text{max}}$ are the minimum and maximum values of the embedding factor.
Insertion of Visible Watermark

Block Diagram showing Visible Watermark Insertion
Host and Watermark Images

Host Image

Watermark Image
Watermarked Images

Watermark over the whole image  Small Watermark at a corner
Scaling and Embedding Factors for “Hardware” Image

Scaling Factors

Embedding Factors
Modifications to make Watermark Robust:

• After getting the $\beta_n$ values we classify them two three different groups.
• If more than 1/3 of blocks have the same value then we generate Gaussian Random Number with mean same as image mean and variance 1, and scale to the range 0 to $(\beta_{\text{max}} - \beta_{\text{min}})/2$.
• Then the numbers are added to (subtracted from) $\beta_n$ of the largest group.
• The $\alpha_n$ values are not disturbed to preserve the quality of the image.
Watermarked “Hardware” Image

Hardware image  Watermarked ‘Hardware’ image
Conclusions and Future Work

• A visible watermarking technique has been proposed in DCT domain.
• A mathematical model is developed for this purpose exploiting the texture sensitivity of the HVS.
• A modification is proposed to increase the robustness of the watermark when used for images with very few objects.
• The typical values of $\alpha_{\text{min}}$, $\alpha_{\text{max}}$, $\beta_{\text{min}}$ and $\beta_{\text{max}}$ are 0.95, 0.98, 0.07 and 0.17 respectively.
• The visible watermark can be used in digital TV, digital library, e-commerce etc.