# Embedding algorithm

Common subimages of left and right views are determined based on minimal MSE difference as proposed in [1].

Haar type 2D DWT transform is computed on the common subimages. In each 8x8 area related to coefficients in the 3rd level of wavelet decomposition, the coefficients with the highest absolute are used for embedding.

The areas that are enabled for embedding are selected with a "noise gate" filter in a similar way as it is used in [3] for audio carrier signals. The "noise gate" filter in this application is a 3x3 "range filter" (difference of min and max values within an area) followed by a Canny edge detector, followed by a binary dilation operator. The full resolution noise gate output map is resized to 1/8 size, in order to get one decision for each 8x8 area related to the DWT coefficients. In the resizing operation the majority of the elementary decisions in each 8x8 area gives the final decision for the given area.

The 8x8 areas that are enabled by the "noise gate" are sorted with respect to the highest absolute value coefficient in the area.

The embedding formulae for the final list of coefficients is the 3rd variant proposed in [2], with embedding strength of 0.1.

The modified coefficients are then put back to their position in the DWT decomposition and the inverse DWT is applied to the coefficients.

The watermark values that are grayscales pixels of a small picture, are scaled into the [0..1] range for embedding. The values are decomposed into 5 slices, each part representing the value in the [0 .2], [.2 .4], [.4 .6] [.6 .8] and [.8 1] range, respectively and these parts are embedded into the subsequent video frames after rescaling to the [0 1] range. During extraction these parts are summed in the last 5 processed frames, with correct scaling.

# Extracting algorithm

The selection of coefficients is done exactly the same way as described for embedding, using the original video sequence. The corresponding original and modified coefficients are then used to estimate the embedded watermark, as proposed in [2]. For measuring the similarity between the original watermark and extracted estimation the cross-correlation function is used.

# Attacks

Three types of attacks are used to test the robustness of the algorithm:

* compression with H264 encoder/decoder with different levels of constant quantizer
* cropping the frame area at both left and right sides of both left and right views
* dropping different numbers of frames after one kept frame

In all cases the bit depth (10 bits per sample), color space (YCrCb) and chromatic subsampling (4:2:2) are unchanged. For each attack type and strength the correlation between the extracted and the original watermark is measured for the 5 first frames.

Compression attack (left view)

Drop attack (left view)

Crop attack (left view)

All measurement data can be found in the attached "attacks.xslx" file with diagrams for both left and right views. The measurement are done on the 3D\_41\_LEFT.mov and 3D\_41\_RIGHT.mov test video of the RMIT3DV library.

# References

[1] Yueh-Hong Chen, Hsiang-Cheh Huang: A Wavelet-based Image Watermarking Scheme for

Stereoscopic Video Frames, Ninth International Conference on Intelligent Information Hiding and Multimedia Signal Processing, 2013

[2] I. J. Cox, M. L. Miller, J. A. Bloom, J. Fridrich, and T. Kalker, Digital Watermarking and Steganography. Science & Technology, 2007.

[3] A Novel Embedding Method to Increase Capacity and Robustness of Low-bit Encoding Audio Steganography Technique Using Noise Gate Software Logic Algorithm, Mohamed A. Ahmed, Miss Laiha Mat Kiab, B.B. Zaidan, Journal of Applie dSciences, 2010.