EEE 6081 (EEE 421)
Visual Information Engineering
Coursework 2011
Dr Charith Abhayaratne

Total Marks: 20 (This contributes to 25% of the overall module marks)

TITLE: Wavelet-based image watermarking: An Inquiry-based learning exercise

Coursework contains two parts:
1) Preliminary Observations on Wavelets Transforms (POWT)
 - 10 Marks
 - Due by 23.59hrs BST on 11th April
2) Wavelet-based image watermarking experiment
 - 10 Marks
 - Due date : please refer to the timetable in part 2.

Part 1 - Preliminary Observations on Wavelet Transforms (POWT)

What is required?
The aim of this part of the exercise is to learn the characteristics of the wavelet decomposed image subbands and how to use these characteristics in visual information engineering applications. During the process of the exercise you will learn the following concepts:

1) The energy conservation property of the wavelet transform
2) The energy distribution among different sub bands
3) The effect of coefficient quantization on image approximation
4) How these properties are exploited in image compression

Steps:
1) Download the wavelet transform files form the software codes folder in MOLE.
2) Download the image assigned to you (Refer to Appendix A)
3) Fill in the form in Appendix B by performing the experiment specified in the form
4) Submit it via the submission tool available in the coursework folder in MOLE

Part 2 - Wavelet-based image watermarking experiment

Watermarking - Background
Watermarking is used as a popular content protection scheme for both digital media and hard copy versions of images. In watermarking, a binary logo or some data of a random pattern is embedded to an image. These watermarked data can be either visible or invisible. In digital media, we are interested in only the latter case. If the watermarked image is modified by someone (by means of adding noise, cropping, compression, rotation, scaling etc) it can be detected by comparing the extracted watermark with the original watermark. For a research review in watermarking you can refer to [1] - [5].

In this experiment we are interested in non-blind water marking. That means at the time of watermark extraction you have the original image with no watermark. Therefore you can find the difference between the non-watermarked image and the watermarked image to find watermarking information.

There are several ways to embed watermarks. We only consider the method known as "direct modification". The watermark can be embedded in pixel domain (that is by modifying the pixel values itself) or by modifying the wavelet transformed coefficients. The main two requirements are

1) it should be imperceptible after embedding, and
2) it should be robust to compression (that means the watermark should be affected minimally due to compression)

The main problem you have to find the answer in this coursework is:
"What are the best wavelet coefficients for embedding a watermark using the direct modification method in non-blind watermarking while meeting the requirements on imperceptibility and robustness to compression?"

We summarise the watermark embedding process as

Image → (FWT) → (Choosing the wavelet coefficient to embed) → (embedding using direct modification) → (IWT) → watermarked image

Process 1

Direct modification for a binary logo performs the following

$$c' = c + c\, a\, w_b \qquad \text{--------------------} \quad (1)$$

c is the original wavelet coefficient value
c' is the modified wavelet coefficient value

a is the amplification constant (You can choose any value for this)

w_b is the watermarked value if the logo value b=1, we can choose, for example w_1=0.9
if the logo value b=0, we can choose, for example w_0=0.3

The visual quality of the watermarked image is compared to the original image using the peak signal to noise ratio (PSNR)

Now the detection process:

You have the watermarked image and the original image.

Image → (FWT) → c

Process 2

Watermarked image → (FWT) → c'

Process 3

Now at the decoder, if c and c' are known the watermark can be extracted using reversing the process shown in Eq.(1)

The accuracy of the extracted watermark is verified by computing the Hamming distance with respect to the embedded watermark.

Now consider the scenario: the watermarked image is transmitted along a communication channel. Before transmission it needs to be compressed. When compressed, the image information is lost. Depending on which coefficients are used for watermarking and which coefficients are quantized heavily, the watermark information can be lost too. But if you choose the embedding coefficient carefully, you can retain the robustness while retaining the imperceptibility.

For this experiment, you can use our watermark embedding and evaluation software (WEBCAM) from http://svc.group.shef.ac.uk/webcam.html (The website includes all guidelines for installation and usage of software). A WEBCAM problems discussion thread will be available via MOLE.

This part of the course work has both individual and team work. Refer to Appendix A to find out your team mates.

Part 2.1: Individual work (4 marks)

1. Download the image allocated to you from the coursework folder in MOLE.
2. Download and install WEBCAM software
3. Using the tools available in WEBCAM software find what are
    a. the best sub bands,
    b. the best coefficients and
    c. the optimum embedding parameters

   for achieving balanced imperceptibility and robustness to compression for image watermarking. (you may want to try 4 bits per pixel (bpp), 2 bpp, 1 bpp, 0.5 bpp and 0.25 bpp compression scenarios.
4. Report your findings (using a single page of A4) by 23.59 hrs (BST) on 6th May 2010 using the drop box in MOLE.

Part 2.2: Team work (3 marks)

1. The submitted reports will be available to your team mates on 7th May 2010.
2. Read the findings of your team mates and compare to see if they are the same as yours or if they are any different.
3. Discuss any differences/similarities with your team mates by using the chat room created for you in MOLE or by any other means.
4. You may want to re run the experiments using WEBCAM to check whether claims by your team mates are accurate.
5. Make your conclusions and present it to the rest of the class on the presentation day. Each team will get 5 minutes and allowed to use at most 4 slides. The presentation day is on 12th May 2010 (during the normal lecture time)

Part 3.4: A short quiz – individually assessed (3 marks)

1. This will be held on 16th May 2010.

The key dates:

28th March	Coursework introduction
30th March	Online resources available via MOLE
7th April @ 15.10 BST	WEBCAM support session (Deep Bhowmik)
11th April @ 23.59 BST	Submit Part 1 to MOLE
3rd May @ 13.10 BST	WEBCAM support session 2 (Deep Bhowmik)
8th May @ 23.59 BST	Submit part 2.1 to MOLE
9th May	Availability of reports of your team mates via MOLE and discussion threads
12th May @ 15.10 BST	Presentation day
16th May @ 15.10 BST	Quiz

Resources

You can find the matlab codes for the following functionalities in MOLE (coursework folder)

- FWT F2DWT.m
- IWT I2DWT.m
- PSNR psnr.m
- Entropy (for wavelet decompositions) SBentropy.m
- Entropy (for images) ent.m

In addition you will have to download Normailse.m and UnNormalise.m as support functions for wavelet m-files.

Images: Please refer to Appendix A for the test image allocated to you. You can download it from the coursework folder

You can also download the logo image logo.mat from the same folder

References

[1] G C Langelaar, I Setyawan and R L Jagendijk, "Watermarking Digital Image and Video Data" IEEE S Signal Processing Magazine, September 2000, pp 20-46.
[2] C I Podilchuck and E J Delp, "Dogital Watermarking algorithms and Applications", IEEE Signal Processing Magazine, July 2001, pp 33-46.
[3] I J Cox and M L Miller, "The First 50 Years of Electronic Watermarking", EURASIP Journal on Applied Signal Processing 2002, No. 2, 126–132.
[4] J R Kim and Y S Moon, "A robust wavelet-based digital watermarking using level-adaptive thresholding" International Conference on Image Processing, 1999. Vol. 2, pp 226-230.
[5] http://www.business-sites.philips.com/contentidentification/home/index.page

Appendix A

Student Name	Image ID
Team 1	
N. Alkhaldi	1
S. Odjaghy	2
L. CUI	3
J. KHALIFAT	4
Team 2	
M. Kang	5
V. Kok	6
M. Li	7
S. Sankaralingam	8
S. Janus	23
Team 3	
H. Liu	9
A. Hidalgo López	10
A. Katta	11
S. SINGH	12
P. Oliveira Pinheiro	24
Team 4	
A. AlHarbiy	13
W. Hotrakool	14
X. Ji	15
Y. Jiang	16
J. Song	17
Team 5	
S. Auckloo	18
M. Brown	19
D. Hewitt	20
C. Wright	21
Y. Sheng	22
Team 6	
P. Perez Bernal	25
R. Wang	26
K. Zhang	27
Y. Zhang	28
H. Zhao	29
Team 7	
Y. Zhao	30
X. Lu	31
M. Su	32
F. Zhu	33