A/L/TY

Reg. No: 22BCI0189

VIT
Vellore Institute of Technology

Final Assessment Test – November 2025

Course: BCSE323L - Digital Watermarking and Steganography
Class NBR(s): 1487/1494
Slot: F1+TF1
Time: Three Hours
Max. Marks: 100

- KEEPING MOBILE PHONE/ANY ELECTRONIC GADGETS, EVEN IN 'OFF' POSITION IS TREATED AS EXAM MALPRACTICE
- DON'T WRITE ANYTHING ON THE QUESTION PAPER

COs	CO Statements
CO1	Learn the fundamental concepts, principles, characteristics and performance measures of digital watermarking and steganography.
CO2	Acquire the various concepts of watermarking for digital authentication and authorization schemes related to electronic documents, image and video.
CO3	Gathering the various concepts of steganography to access the sensitive information concealing of message, image, audio or video within another file.
CO4	Design and implement efficient data hiding methods against steganalysis techniques.

BL – Blooms Taxonomy Level (1 – Remember, 2 – Understand, 3 – Apply, 4 – Analyse, 5 – Evaluate, 6 – Create)

Answer ALL Questions
(10 X 10 = 100 Marks)

1. The Aquamark receiver uses even parity for error detection and correction with Hamming (7,4) code. A watermarked data sequence 1011011 has been received at the destination. Identify the error in the sequence and correct it. After correction, extract the original data word from the received data. **CO1 BL2**

2. A company wants to embed ownership data in its images to prevent misuse. Consider the two watermarking schemes: Either embed a single-bit indicating ownership (e.g., 1 = "owned", 0 = "not owned") or embed a multi-bit ID code (e.g., company name, timestamp, and license no.). **CO1 BL2**
   I. Compare single-bit and multi-bit watermarking in terms of payload capacity, robustness, and detection reliability.
   II. If the images are likely to undergo compression and minor editing before distribution, which scheme would be more suitable and why?
   III. If the company wants to track individual licensees through unique IDs, how would that influence your choice of watermarking scheme?

3. Given a 4×4 image matrix M, compute the Haar transform using averaging and differencing technique. Demonstrate how the watermark W can be embedded into the LL subband (Low frequency) using multiplicative embedding with α=0.1 **CO2 BL2**

$$M = \begin{bmatrix} 52 & 50 & 61 & 59 \\ 48 & 50 & 54 & 52 \\ 45 & 47 & 48 & 46 \\ 47 & 47 & 45 & 43 \end{bmatrix} \qquad W = \begin{bmatrix} -1 & 1 \\ -1 & 1 \end{bmatrix}$$

4. An image M is transformed using the DCT kernel K, and a watermark embedding process is applied, resulting in the output D. Determine whether the original image M can be fully recovered from D. Justify your conclusion with appropriate reasoning and supporting steps. **CO2 BL2**

$$D = \begin{bmatrix} 17.0 & 3.41 & 0.5 & 0.62 \\ -2.79 & -1.3552 & -1.54 & 2.4514 \\ -0.5 & 0.4 & 1 & -5.55 \\ -0.54 & 2.4514 & 2.79 & 0.3552 \end{bmatrix}$$

$$K = \begin{bmatrix} 0.5 & 0.5 & 0.5 & 0.5 \\ 0.65 & 0.27 & -0.27 & -0.65 \\ 0.5 & -0.5 & -0.5 & 0.5 \\ 0.27 & -0.65 & 0.65 & -0.27 \end{bmatrix} \qquad M = \begin{bmatrix} 4 & 4 & 2 & 2 \\ 4 & 3 & 8 & 3 \\ 8 & 2 & 4 & 3 \\ 5 & 8 & 2 & 6 \end{bmatrix}$$

5. Consider the quantized DCT coefficients represented by the 8x8 matrix D for JSteg embedding. Embed the secret message [1,0,1,0,0] into the appropriate coefficients using LSB embedding in row-major order. Demonstrate how the modified coefficient matrix is transformed into the zig-zag sequence, and explain the process of Huffman encoding applied on the sequence after truncating the trailing zeros. **CO1 BL2**

$$\mathrm{D} = \begin{bmatrix} 24 & 6 & 6 & 5 & 0 & 0 & 0 & 0 \\ 4 & 1 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 4 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

6. An insider is suspected of using image steganography with a stego key to secretly transmit sensitive company data. The method used provides high embedding efficiency and strong statistical undetectability. Discuss how the attacker can balance steganographic capacity, embedding capacity, and fidelity to minimize the chance of detection. As a forensic analyst, explain how you would employ blind and targeted steganalysis to detect the hidden data, considering the effects of false alarm rate, system steganalysis, and overall security of the stego system. **CO1 BL2**

7. "Three main aspects in audio steganography are the DOE, MODI, and carrier type." Explain each of these aspects in detail with examples. **CO3 BL4**

8. Consider the Generator matrix G for a (4, 2) Ternary Hamming code with ± 1 embedding. Derive the Parity check matrix and embed the message m = [2, 2] into the pixels [15, 17, 20, 25]. **CO3 BL4**

$$G = \begin{bmatrix} 1 & 0 & 1 & 2 \\ 0 & 1 & 2 & 1 \end{bmatrix}$$

9.a) The image X represents the watermark-embedded output obtained using histogram shifting with a zero point of 6 and a peak point of 4. The embedding process was carried out by LSB embedding into the appropriate pixels in row-major order. Extract the watermark bits from X and restore the original pixel values. **CO2 BL4**

$$X = \begin{bmatrix} 3 & 5 & 4 & 2 \\ 5 & 3 & 5 & 6 \\ 3 & 4 & 3 & 2 \\ 2 & 3 & 5 & 4 \end{bmatrix}$$

OR

9.b) Explain each of the following attacks using appropriate diagrams and recommend the countermeasures: **CO2 BL4**

Attack 1: Removes watermarks when the attacker has access to a detector that only returns a yes/no (i.e., detected/not detected) as output.

Attack 2: Removes watermarks when the attacker has a detector that reports detection values (not just yes/no).

10.a) Because F5 embedding preserves the symmetry of the histograms, the attack strategy that targets Jsteg algorithm is not applicable for F5 algorithm. Explain how targeted steganalysis can be performed on F5 algorithm using calibration. **CO4 BL4**

OR

10.b) Eve, a digital forensics expert, is investigating images that may contain hidden messages. She must decide whether an image x is a cover or a stego image. CO4 BL4

I. If Eve has knowledge of the stegosystem, explain how can she model the cover image distribution and stego image distribution, formulate hypothesis tests, and apply the likelihood-ratio test to distinguish between the two?

II. How does the detection problem change and what type of hypothesis test does it become if Eve has no knowledge of the embedding process?

III. If Eve knows the algorithm but not parameters like the embedding rate, how can the detection problem be expressed as a composite one-sided test?

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