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Vellore Institute of Technology

(Deemed to be University under section 3 of UGC Act, 1956)

SCHOOL OF COMPUTER SCIENCE AND ENGINEERING
CONTINUOUS ASSESSMENT TEST - I
FALL SEMESTER 2025-2026

Course Code and Course Name : BCSE323L /Digital watermarking and Steganography

Answer Key

<table>
<tr><th>Q. No</th><th>Question</th></tr>
<tr><td>1.</td><td>An owner owns a video and has secured it by embedding an authentic watermark. He allowed ‘copy once’ for promotional reasons but soon he found that there is misuse of rights and many second-generation copies have been floated in the internet. The owner would like to improve the security of watermarking and make it more effective. He would want a more robust watermark that withstands cropping and other transformations. Suggest and discuss about a watermarking system with specific properties suitable for the current scenario.

Answer:
Frequency domain watermarking, Cryptographic techniques, Multiscale, Redundant, Random Sequence generation, Multiple watermarking, Spread Spectrum, etc.</td></tr>
<tr><td>2.</td><td>a) In the communication-based model of watermarking, assume that the cover work is considered as noise, but this noise is not provided to the channel encoder as side information. With this assumption, design a watermarking system with Blind Embedding and Linear Correlation Detector. Assume the message to be a single bit message.
b) Discuss how different is the model in question 2)a) from watermarking with side information.

Answer: A)Blind embedding and linear correlation detection:
Embedder:
1. Choose a random reference pattern. This is simply an array with the same dimensions as the original image, whose elements are drawn from a random Gaussian distribution in the interval [-1, 1]. The watermarking key is the seed that is used to initiate the pseudo-random number generator that creates the random reference pattern.
2. Calculate a message pattern depending on whether we are embedding a 1 or a 0. For a 1, leave the random reference pattern as it is. For a 0, take its negative to get the message pattern.
3. Scale the message pattern by a constant α which is used to control the embedding strength. For higher values of α we have more robust embedding, at the expense of loosing image quality. The value used at the initial experiment was $\alpha = 1$.
4. Add the scaled message pattern to the original image to get the watermarked image.
Detector:
1. Calculate the linear correlation between the watermarked image that was received and the initial reference pattern that can be recreated using the initial seed which acted as the watermarking key.
2. Decide what the watermark message was, according to the result of the correlation. If the linear correlation value was above a threshold, we say that the message was a 1. If the linear correlation was below the negative of the threshold we say that the message was a 0. If the linear correlation was between the negative and the positive threshold we say that no message was embedded.

B) Informed embedding and linear correlation detection</td></tr>
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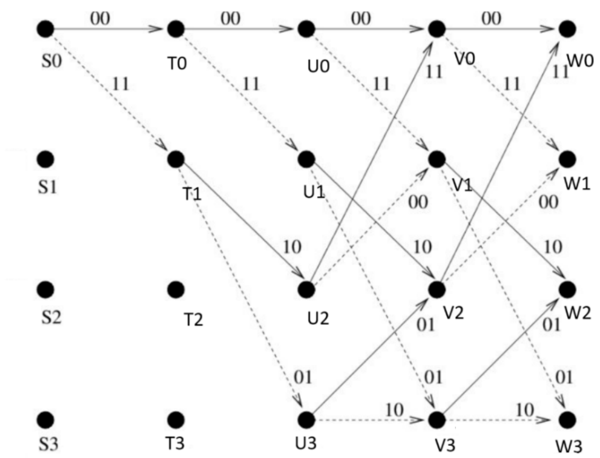
The difference between this model and the model of (A) is the use of the original image. The watermark embedder still encodes a message using not only a key but also the information provided by the original image. The resulting encoded message is then added to the original image as in the case of the no-side-information model. The noisy transmission channel adds some more noise, and the watermarking detector tries to get the original message back using the original key and a detection algorithm. Calculate the α constant using the linear correlation between the watermarked image and the message pattern. The goal is to ensure that the linear correlation value used for the watermark detection is always some constant, greater than the detection threshold. We substitute this value in the left hand side of the linear correlation equation and solve for α. In this way we get a different value for α for every image.

ALSO GIVE BLOCK DIAGRAMS.

3. Consider the following state transition diagram of Trellis code where there are 5 states namely S, T, U, V and W.



Assume that the received vector is 00 11 11 01.

a) Write a brief note on how a 4-bit message (multibit message) can be encoded using a 5-state transition diagram to give a 8-bit codeword. Discuss also how the encoded message can get corrupted during transmission and is received in the detector.

On the detector's end, do the following.

b) Decode the most likely path through the Trellis using Viterbi algorithm in steps.
c) Detect and correct errors if any.
d) Decode the embedded message.

ANSWER: (a)The encoder can be implemented as a state machine. The machine begins in state S and processes the input bits one at a time. As it processes each input bit, it outputs 2 bits and changes state. If the input bit is a 0, it traverses the light arc coming from the current state and outputs the 2 bits with which that arc is labeled. If the input bit is a 1, it traverses the dark arc and outputs that arc's 2-bit label. So, a 4-bit message will be transformed into an 8-bit code word after encoding
(b) Path: S0->T0->U1->V3->W2
(c) Error corrected answer: 00110101
(d) decoded as 0110 or 1001 (based on your assumption about the dotted lines and bold lines)

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4. A client wanted to perform denoising of his proprietary image given by f(x,y). He approached an image processing expert in this regard. The idea now is to filter out the noise frequency from the frequency transformed coefficients of the given image. Help the expert in deriving a 4-point Discrete Fourier transform (DFT) kernel and apply it on the image f(x,y) to obtain the DFT coefficients.

$$f(x,y)=\begin{bmatrix}1 & 0 & 1 & 1\\ 0 & 1 & 1 & 0\\ 1 & 0 & 1 & 1\\ 1 & 1 & 0 & 0\end{bmatrix}$$

ANSWER:

$$=\frac{1}{N}\times \text{kernel} \times f[m,n] \times (\text{kernel})^T$$

$$=\begin{bmatrix}1 & 1 & 1 & 1\\ 1 & -j & -1 & j\\ 1 & -1 & 1 & -1\\ 1 & j & -1 & -j\end{bmatrix}\times\begin{bmatrix}1 & 0 & 1 & 1\\ 0 & 1 & 1 & 0\\ 1 & 0 & 1 & 1\\ 1 & 1 & 0 & 0\end{bmatrix}\times\begin{bmatrix}1 & 1 & 1 & 1\\ 1 & -j & -1 & j\\ 1 & -1 & 1 & -1\\ 1 & j & -1 & -j\end{bmatrix}\times\frac{1}{4}$$

$$=\begin{bmatrix}3 & 2 & 3 & 2\\ j & 0 & -j & 0\\ 1 & -2 & 1 & 2\\ -j & 0 & j & 0\end{bmatrix}\text{x}\begin{bmatrix}1 & 1 & 1 & 1\\ 1 & -j & -1 & j\\ 1 & -1 & 1 & -1\\ 1 & j & -1 & -j\end{bmatrix}\text{ x }\frac{1}{4}$$

$$=\begin{bmatrix}2.5 & 0 & 0.5 & 0\\ 0 & 0.5j & 0 & 0.5j\\ 0.5 & j & 0.5 & -j\\ 0 & -0.5j & 0 & -0.5j\end{bmatrix}$$

5. It is decided to embed the watermark given by W into a cover work given by A. Hadamard transform is chosen for its simple calculations. Apply the same over the image A and embed the given watermark W using additive embedding. Use scaling factor, α=0.1 and find the resulting transformed matrix.

$$W=\begin{bmatrix}1 & 1 & 1 & 1\\ 0 & 1 & 1 & 0\\ 1 & 0 & 1 & 1\\ 1 & 1 & 1 & 0\end{bmatrix}\qquad A=\begin{bmatrix}1 & 3 & 2 & 1\\ 1 & 2 & 2 & 0\\ 1 & 2 & 1 & 1\\ 1 & 1 & 1 & 2\end{bmatrix}$$

ANSWER:

$$X[N]=\frac{1}{N}\times H[N]\times x(n)\times H[N]$$

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$$= \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -1 & 1 & -1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \end{bmatrix} \times \begin{bmatrix} 1 & 3 & 2 & 1 \\ 1 & 2 & 2 & 0 \\ 1 & 2 & 1 & 1 \\ 1 & 1 & 1 & 2 \end{bmatrix} \times \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -1 & 1 & -1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \end{bmatrix} \times \frac{1}{4}$$

$$= \begin{bmatrix} 5.5 & -0.5 & 0.5 & -1.5 \\ 0.5 & -0.5 & 0.5 & -0.5 \\ 0.5 & 0.5 & 0.5 & -1.5 \\ 0.5 & -0.5 & -0.5 & 0.5 \end{bmatrix}$$

Additive embedding: ***h****(*i*, *j*) = ***h***(*i*, *j*) + ***a***(*i*, *j*) ***w***(*i*, *j*)

$$= \begin{bmatrix} 5.5 & -0.5 & 0.5 & -1.5 \\ 0.5 & -0.5 & 0.5 & -0.5 \\ 0.5 & 0.5 & 0.5 & -1.5 \\ 0.5 & -0.5 & -0.5 & 0.5 \end{bmatrix} + \begin{bmatrix} 0.1 & 0.1 & 0.1 & 0.1 \\ 0 & 0.1 & 0.1 & 0 \\ 0.1 & 0 & 0.1 & 0.1 \\ 0.1 & 0.1 & 0.1 & 0 \end{bmatrix} = \begin{bmatrix} 5.6 & -0.4 & 0.6 & -1.4 \\ 0.5 & -0.4 & 0.6 & -0.5 \\ 0.6 & 0.5 & 0.6 & -1.4 \\ 0.6 & -0.4 & -0.4 & 0.5 \end{bmatrix}$$