Project A

Performance Evaluation of Edge Detection Techniques in Digital Images

Description: Edge detection is one of the most widely used procedures in digital image processing. Research efforts in this field have resulted in a large number of algorithms. Those could be classified into (a) Gradient edge detectors, (b) Morphologic edge detectors, (c) Edge map creating, (d) Zero-crossing detectors as well as the latest works involving (d) fractional derivatives for edge detection. Figure 1 gives an example of an image and its edge-detected version.

Outcome: The student is expected to carry out a comprehensive study on edge detection technique, comparing and contrasting the advantages and disadvantages of each. In doing so, a thorough study of the edge detection categories has to be carried out and the various performance evaluation metrics should be investigated and calculated for each.

Fig. 1. Original image on the left and edge detection on the right.

Project B

Performance Evaluation of Multi-Hop Multi-Branch Hybrid AF/DF Relaying Networks

Description: Cooperative communications has been regarded as a major pillar of wireless networking due to its potential of increased spatial diversity, system capacity and improved cellular coverage. Two forwarding protocols are commonly used at any given relay node, those are amplify-and-forward (AF) and decode-and-forward (DF). AF is simple to implement, but might not always result in the best possible error performance. On the other hand, DF usually provides improved error performance, but at the cost of a higher system complexity. A hybrid scheme that toggles between AF and DF is usually implemented to reap the benefits of each. The toggling at a relay node between the 2 forwarding protocols is usually based on the calculation of a metric and comparing it with a threshold. To achieve good error performance at long ranges of wireless communications, a multi-hop, multi-branch network could be employed. The system model of such a network is shown in Fig. 2.

Outcome: The student is expected to study and implement a multi-hop, multi-branch wireless communication network using a computer package. The student is expected to simulate the network using AF relays, DF relays and hybrid AF/DF relays. The student is expected to compare the 3 forwarding protocols for the network using the error performance as a benchmark. A computer package such Mathworks Matlab or Wolfram Mathematica could be used for the implementation.

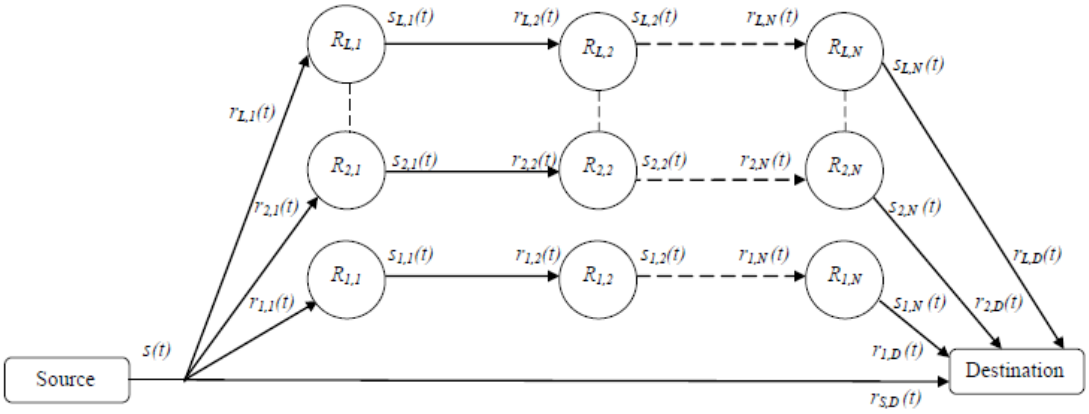

Fig. 2. A hybrid AF/DF multi-hop multi-branch relaying network.

Project C

Log-likelihood Ratio Based Hybrid On-Off Relaying in Rayleigh Fading

Description: Cooperative communications has been regarded as a major pillar of wireless networking due to its potential of increased spatial diversity, system capacity and improved cellular coverage. Two forwarding protocols are commonly used at any given relay node, those are amplify-and-forward (AF) and decode-and-forward (DF). AF is simple to implement, but might not always result in the best possible error performance. On the other hand, DF usually provides improved error performance, but at the cost of a higher system complexity. A hybrid scheme that toggles between AF and DF is usually implemented to reap the benefits of each. In this project, a decision is made at the beginning of every transmission regarding whether or not a relay node will be activated. In case of relay node activation, a single one is selected out of the *N* available nodes to assist the source in relaying its message signal to the destination. The selected relay node will employ a hybrid AF/DF protocol.

Outcome: The student is expected to study and simulate a cooperative communication network using a computer package such Mathworks Matlab or Wolfram Mathematica. The student is expected to simulate the network using AF relays, DF relays and hybrid AF/DF relays. The student is expected to compare the performance of the network in terms of error, outage and capacity curves.

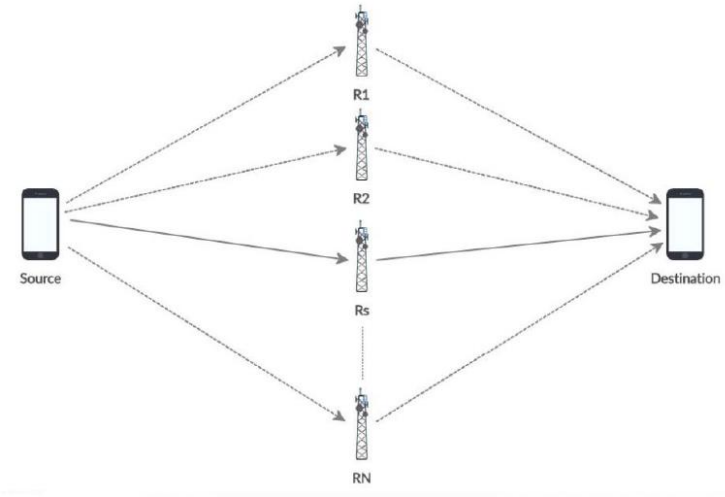

Fig. 3. A hybrid AF/DF relaying network which selects a single relay out of *N* available ones.

Project D

Chaotic Function Secured Message Steganography in Edge-Detected Pixels of 3D Images

Description: The rapid development of the fields of image processing and multimedia allows for secure data communication in unprecedented ways over unsecure channels. Novel schemes that employ a combination of cryptography and steganography to secure sensitive data transmission over the internet are being developed every day. In this project, **a chaotic function** is used to generate a secret key for message encryption. Next, a 3D image, as shown in Fig. 4, is sliced into a large number of 2D slices, as shown in Fig. 5, and LSB-embedding of the secured data bit stream is carried out in its pixels. For increased security, an edge detection algorithm is implemented on each of the 2D slices and the embedding is only carried out in edge bits. The edge detection algorithm to be used in this project is ***Canny*, a first-order directional Gaussian derivative algorithm.**

Outcome: The student is expected to gain knowledge about cryptography, steganography and image processing before starting the implementation of the multiple-layer security scheme. A computer package such Mathworks Matlab or Wolfram Mathematica could be used for the implementation. A number of performance evaluation metrics will be computed and compared with counterpart message security schemes from the literature.

Fig. 4. A part of an engine is modeled as a 3D image and used here as the cover object.

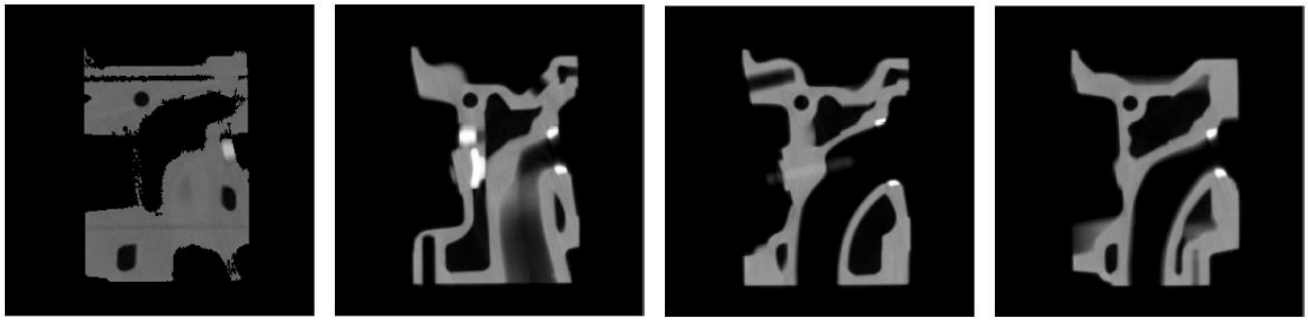

Fig. 5. Some 2D slices of the 3D cover image.

Project E

Advanced Encryption Standard Secured Message Steganography in Edge-Detected Pixels of 3D Images

Description: The rapid development of the fields of image processing and multimedia allows for secure data communication in unprecedented ways over unsecure channels. Novel schemes that employ a combination of cryptography and steganography to secure sensitive data transmission over the internet are being developed every day. In this project, the world standard in encryption, **AES-256** is used to generate a secret key for message encryption. Next, a 3D image, as shown in Fig. 6, is sliced into a large number of 2D slices, as shown in Fig. 7, and LSB-embedding of the secured data bit stream is carried out in its pixels. For increased security, an edge detection algorithm is implemented on each of the 2D slices and the embedding is only carried out in edge bits. The edge detection algorithm to be used in this project is ***Sobel*, an algorithm using a binomial generalization of Sobel masks**.

Outcome: The student is expected to gain knowledge about cryptography, steganography and image processing before starting the implementation of the multiple-layer security scheme. A computer package such Mathworks Matlab or Wolfram Mathematica could be used for the implementation. A number of performance evaluation metrics will be computed and compared with counterpart message security schemes from the literature.

Fig. 6. A 3D image resulting from magnetic resonance imaging (MRI) of a human knee and used here as the cover object.

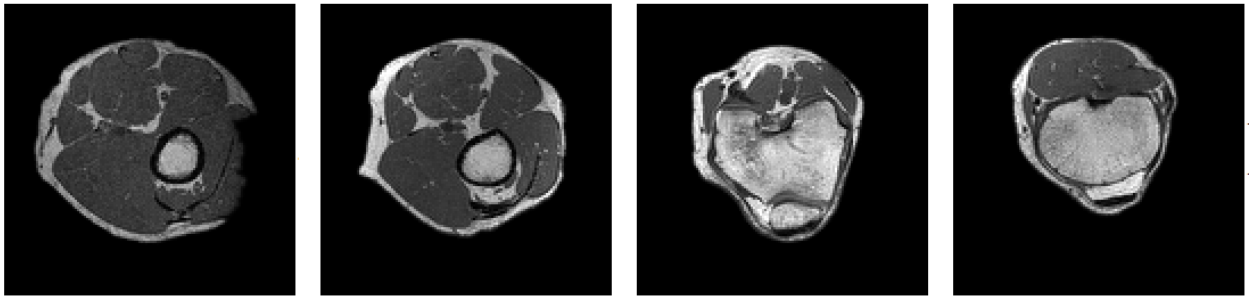

Fig. 7. Some 2D slices of the 3D cover image.